United States
Department of
Agriculture

Forest Service
Southern Region

Insects and Diseases of Trees in the South

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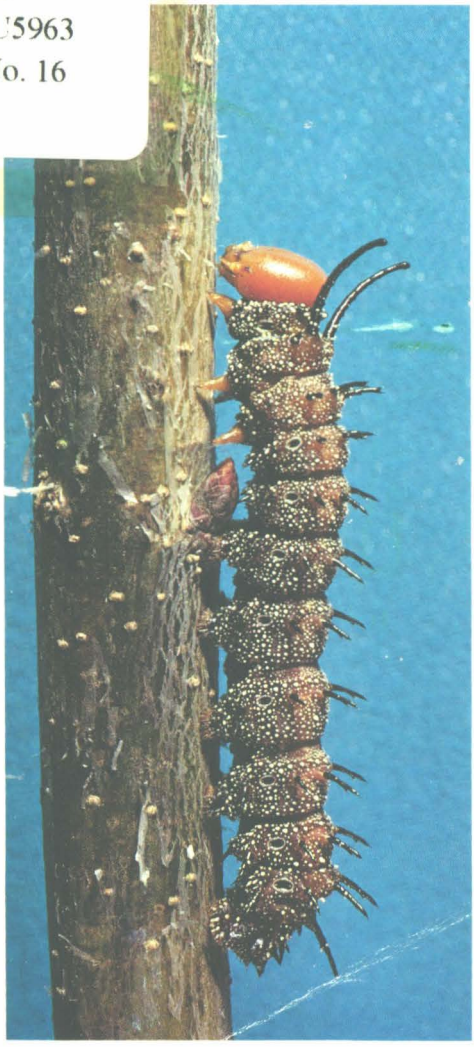

June 1989

Protection Report R8-PR 16

INTRODUCTION

This publication has been prepared to assist forest managers and home-owners in identifying pests of southern trees. The insects and diseases discussed are the more common ones attacking forest and ornamental trees. Prompt identification and treatment of these pests may mean the difference between losing or saving a valuable shade tree. Underlying all successful forest and ornamental pest control efforts, however, is the necessity to keep trees in a healthy, vigorous condition. Chemical supression recommendations are not included in this publication. For pesticide information contact the local State or Federal extension specialist, forester, entomologist, or pathologist.

Credit for some of the pictures in this guide goes to the Southern and Southeastern Forest Experiment Stations and universities. We acknowledge the help of the Forest Pest Management field personnel who assisted in compiling this booklet. To all involved — thank you.

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Cover Pictures. Spiny oakworm (see page 14) and black knot disease on cherry (see page 57).

This publication supersedes General Report R8-GR 5, June 1985.

TABLE OF CONTENTS

INSECTS

Hardwood Insects

Defoliators

Cottonwood Leaf Beetle 4
Linden Looper 5
Eastern Oak Looper 5
Eastern Tent Caterpillar 6
Elm Leaf Beetle 7
Elm Spanworm 8
Fall Cankerworm 9
Spring Cankerworm 9
Fall Webworm 10
Forest Tent Caterpillar 11
Gypsy Moth 12
Locust Leafminer 13
Orangestriped Oakworm 14
Pinkstriped Oakworm 14
Spiny Oakworm 14
Poplar Tentmaker 15
Slug Oak Sawfly 16
Variable Oakleaf Caterpillar 17
Walkingstick 18
Walnut Caterpillar 19
Whitemarked Tussock Moth 20
Yellownecked Caterpillar 21

Bark Beetles and Borers

Carpenterworm 22
Columbian Timber Beetle 23
Cottonwood Borer 24
Cottonwood Twig Borer 25
Hickory Bark Beetle 26
Locust Borer 27
Red Oak Borer 28
Smaller European Elm Bark Beetle 29
Twolined Chestnut Borer 30
White Oak Borer 31

Piercing and Sucking Insects

Aphids 32
Lace Bugs 33
Scales 34

Conifer Insects

Defoliators

Bagworm 35
Blackheaded Pine Sawfly 36
Introduced Pine Sawfly 37
Loblolly Pine Sawfly 38
Pine Colaspis 39
Pine Webworm 40
Redheaded Pine Sawfly 41
Texas Leafcutting Ant 42
Virginia Pine Sawfly 43

Bark Beetle and Borers

Ambrosia Beetles 44
Black Turpentine Beetle 45
Ips Engraver Beetles 46
Southern Pine Beetle 47
Southern Pine Sawyer 48

Meristem Feeders

Deodar Weevil 49
Nantucket Pine Tip Moth 50
Pales Weevil 51
Pitch-Eating Weevil 52
White Pine Weevils 52

Piercing and Sucking Insects

Balsam Woolly Aphid 53

(Also refer to sections on Aphids and Scales, pages 32, 34)

DISEASES

Hardwood Diseases

Foliage and Twig

Anthracnose 55
Cottonwood Rust 56
Black Knot 57
Leaf Diseases (Powdery Mildew, Leaf Blister, Leaf Spots, and Nutrient Deficiencies) 58, 59

Canker

Nectria Canker 60
Hypoxylon Canker 61
Strumella Canker 62
Chestnut Blight 63

Vascular Wilts

Oak Wilt 64
Dutch Elm Disease 65
Elm Phloem Necrosis 66
Mimosa Wilt 67
Verticillium Wilt 68

Root and Butt Rots and Decay
Canker Rots 69
Heart Rots 70
Lucidus Root & Butt Rot 71
Shoestring Root Rot 72

Conifer Diseases
Foliage
Needle Casts 73
Brown Spot Needle Blight 74
Pine Needle Rust 75
Cedar Apple Rust 76
Phomopsis Blight 77
Stem, Branch, and Cone
Fusiform Rust 78
Comandra Blister Rust 79
Eastern Gall Rust 80
Southern Cone Rust 81
Pitch Canker 82
Root and Butt Rots and Decay
Red Heart 83
Annosus Root and Butt Rot 84
Brown Cubical Rot 85
Red Root and Butt Rot 86
Littleleaf Disease 87
Sand Pine Root Disease 88
White Pine Root Disease 89
Other Diseases
Urban Tree Decline 90
Air Pollution 91
Herbicide Damage 92
Pinewood Nematode 93
Slime Flux 94
Mistletoe 95
Plant Parasites of Tree Roots 96
Glossary 97

COTTONWOOD LEAF BEETLE, *Chrysomela scripta F.*

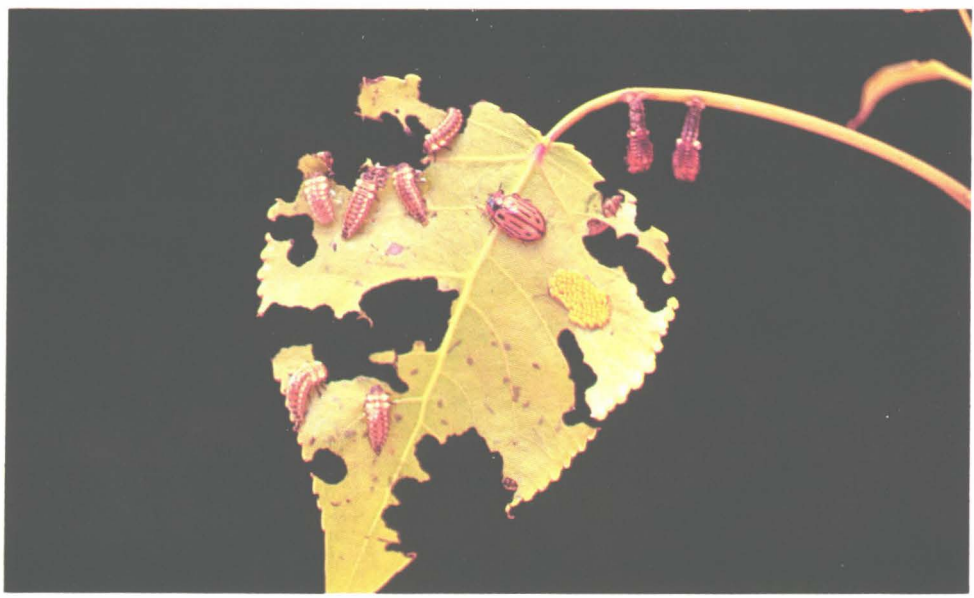
Importance. — Willows, poplars, aspens, and alders are attacked in the eastern half of the United States. Stunting and multiple-forked tops have been especially severe in intensively managed cottonwood plantations. Damage is most critical during the first 3 years after planting and may cause mortality.

Identifying the Insect. — Adults are about ¼ inches (6 mm) long. The head and thorax are black, and the margins of the thorax are yellow or red. The wing covers are usually yellowish with broken black stripes, but are sometimes almost pure golden to black. Young larvae are black, but become light to dark brown with prominent white scent gland spots along their sides. Mature larvae reach about ½ inch (12 mm) in length. The larvae emit a pungent odor when disturbed.

Identifying the Injury. — The young larvae are gregarious and skeletonize the leaves. Later, they feed separately and consume the entire leaf, except the larger veins. Adults chew holes in the leaves, may attack tender shoots, sometimes killing the terminals, causing reduced growth, stem deformity, or even tree mortality.

Biology. — The adults hibernate under bark, litter, and forest debris. Beetles may be collected in large numbers under or near cottonwood or willow trees in the winter. In the spring, after leaf growth begins, they fly to host trees to feed on the leaves and twigs. In a few days, the female beetles begin to lay their lemon-yellow eggs in clusters of 25 or more on the undersides of leaves. The larvae reach full size and pupate in less than 2 weeks. The pupae attach to leaf surfaces, the bark, or to weeds and grass beneath the trees. The adult beetles emerge after 5 to 10 days. There are six to eight generations per year in the South.

Control. — Under forest conditions, they are often held in check by lady beetle predators which feed on the eggs and pupae. Control may be needed in plantations during the first 3 years. Chemical sprays have been successful in nurseries and young plantations.



Typical damage and life stages adults, larvae and pupae.

LINDEN LOOPER,
Erannis Tiliaria (Harris)
and
EASTERN OAK LOOPER,
Phigalia titea (Cramer)

Importance. — The linden looper and eastern oak looper cause defoliation in the spring. Host species attacked include the red and white oak groups, maples, elms, hickories, ash, and cherry. Heavy defoliation usually occurs in May and June and can cause growth loss and mast reduction. If coupled with other stresses, this defoliation may cause mortality. The greatest impact of these insects is often felt in public use areas where defoliation reduces the aesthetic value, and larvae and their droppings create a nuisance.

Identifying the Insect. — Male moth wings are light gray to tan, with wavy lines, and a span of 1 to 1½ inches (25 to 37 mm). Linden looper females are wingless, and the eastern oak looper female has wing pads, but cannot fly.

Mature larvae of these loopers are about 1½ inches (37 mm) long. The eastern oak looper has a tan head and body, with many lengthwise, black, wavy lines. The larval segments have small, hairy tubercles. The linden looper has a rusty brown head, a tan back with numerous wavy black lines, and yellow sides. Coloring of both loopers varies with population densities.

Identifying the Injury. — Early evidences of feeding are small holes in the leaf produced by young larvae feeding on the expanding foliage. Older larvae consume the entire leaf, except the midribs and major veins.

Biology. — Adults emerge and lay their eggs in early spring. Eggs hatch at about the time of bud break, and the young larvae begin feeding on the expanding foliage. Feeding continues for approximately 6 weeks, then the mature larvae enter the soil and pupate.

Control. — The eggs and larvae are attacked by insect parasites and predators. Other natural enemies also help in control. Sticky bands placed around the trunks of high value trees can trap the females as they climb the tree to lay eggs. In high use or high value areas, chemical control may be needed.

Linden looper larva.

Eastern Oak looper larva.

EASTERN TENT CATERPILLAR, *Malscosoma americanum* (F.)

Importance. — The eastern tent caterpillar is primarily an aesthetic problem and has little adverse effect on the host trees. Species of the genus *Prunus* are preferred hosts, with black cherry being the primary, uncultivated host.

Identifying the Insect. — Full-grown larvae are between 2 to 2½ inches (50 to 65 mm) in length. Caterpillars have black heads, with long, light brown body hairs. The back has a light stripe, bordered on each side with yellowish-brown and black wavy lines. The sides are marked with blue and black spots. Moths have a wingspread of about 2 to 2½ inches (50 to 65 mm) and are yellowish-brown, with two narrow, light lines across the front wings.

Identifying the Injury. — The larvae construct a white web or tent in the crotch of a small branch. They consume the entire leaf, except the midrib.

Biology. — Overwintering eggs hatch about the time black cherry buds open in the spring. Young larvae begin to construct a tent and enlarge the structure as they grow. Full-grown larvae construct tough, silken cocoons. Moths emerge in early summer and lay eggs in shiny, dark brown masses around small twigs or branches of host trees.

Control. — Control is not normally necessary. Defoliated trees usually refoliate after being attacked. Chemicals can be used to protect fruit trees, or tents containing the caterpillars may be picked off and destroyed.

Typical tent on cherry.

Larva.

ELM LEAF BEETLE,
Pyrrhalta luteola (Mueller)

Importance.—The elm leaf beetle attacks all species of elm. However, in most of its range, the beetle prefers the Siberian elm. When defoliation is severe for several consecutive years, limbs and sometimes the tree may be killed. The beetles may become a nuisance in the fall when they move into homes searching for overwintering sites. The adults may be a problem in the spring when they congregate in windows as temperatures increase.

Identifying the Insect.—The larvae are green to yellow, with a black head and two black stripes on the back. Pupae are about ¼ inch (6 mm) long and bright orange-yellow. The adults are approximately ¼ inch (6 mm) long and yellowish to green with a black stripe on each wing margin.

Identifying the Injury.—Adults chew holes in the leaves, particularly on new growth. The larvae feed on the under surfaces of leaves, leaving upper surfaces and the veins intact. Leaves shrivel and turn brown when damage is severe.

Biology.—In the spring the adults fly to elms and eat small holes in the newly developing leaves. Eggs are laid in a cluster on the undersides of leaves. The eggs hatch and the larvae feed for 2 to 4 weeks. The larvae crawl to sheltered places on the tree or ground to pupate. In one to two weeks new adults emerge and again feed and lay eggs. There are two to four generations per year, depending on the geographical location.

Control.—No chemical controls are recommended in forest stands. Homeowners may use recommended insecticides to protect valuable shade trees. Sprays should be directed at the undersides of the leaves, beginning in the early spring.

Typical damage and life stages—adults, larvae. and eggs.

ELM SPANWORM,
Ennomos subsignarius (Hubner)

Importance.—The preferred hosts of elm spanworm are red and white oaks and a few other hardwood species, especially hickory, pecan, and related trees. This is a destructive forest pest, particularly in the southern Appalachians, where widespread, severe outbreaks have occured. Repeated defoliation can cause growth loss, dieback, reduction in mast crops, and even mortality.

Identifying the Insect.—Larvae are slate gray to brownish black, with yellowish body markings (yellow or green at low population densities), and 1½ to 2 inches (40 to 50 mm) long. The adults are snow-white moths. The small, barrel-shaped, olive-green eggs are laid in masses on the underside of small branches in the Southeast. To the north, they are found more commonly on the bole.

Identifying the Injury.—Young larvae feed on the edge and undersides of leaves, causing a shothole appearance at low population levels. When populations are high, they consume the entire leaf, except the main veins, giving a feathered appearance to the tree.

Biology.—Overwintering eggs hatch in early spring when the buds break, usually in late April in the South. The larvae feed for 4 to 6 weeks and then pupate in net-like cocoons on the host tree or understory. Six to 10 days later, in late June or mid-July, the moths emerge and deposit their eggs. There is one generation per year.

Control.—Insect parasites attack the eggs of the elm spanworm. Other natural enemies are also important in keeping infestations in check. Chemical controls may be needed to protect high value trees.

Larva.

Feeding damage on leaves.

FALL CANKERWORM,
Alsophila pometaria (Harris)
and
SPRING CANKERWORM,
Paleacrita vernata (Peck)

Importance.—The fall and spring cankerworms defoliate a variety of hardwood species in the spring. Hosts include the red and white oak groups, maples, elms, hickories, ash, and cherry. Heavy defoliation usually occurs in May and June, and can cause growth loss, mast reduction, and, if coupled with other stresses, may result in mortality. Their greatest impact is often felt in high public use areas where defoliation reduces the aesthetic value, and larvae and their droppings create a nuisance.

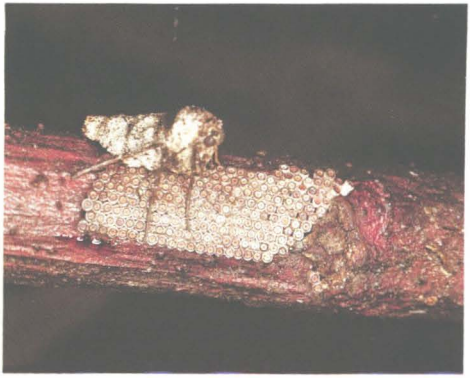
Identifying the Insect.—The wings of male moths are light gray to tan, with wavy lines, and span about 1 to 1½ inches (25 to 37 mm). Females are wingless.

Mature larvae of the fall cankerworm are about 1 inch (25 mm) long and vary from light green to black, with light yellow lines on the sides and a dark dorsal stripe. Mature larvae of the spring cankerworm are $^{4}/_{5}$ to $1\,^{5}/_{10}$ inches (18 to 30 mm) long and range in color from reddish to yellowish brown, yellowish green, or black. The head is light and mottled with a yellow stripe along each side of the body. Coloring of both loopers varies with population density.

Identifying the Injury.—Small holes in the leaves are early evidence of young larvae feeding on expanding foliage. Older larvae consume the entire leaf, except the midribs and major veins.

Biology.—Fall cankerworm adults emerge in the fall following a hard freeze. They overwinter in the egg stage. The spring cankerworm adults emerge in February and March to lay their eggs. For both species, the eggs hatch at about the time of bud break, and the young larvae begin feeding on the new foliage. Feeding continues for approximately 6 weeks, after which the mature larvae enter the soil and pupate.

Control.—The eggs and larvae are attacked by insect parasites and predators. Other natural enemies also help in control. Sticky bands placed around the trunks of high value trees can trap the females as they climb the tree to lay their eggs. In high use or high value areas, chemical control may be needed.



Female moth laying eggs.

Fall cankerworm larva.

FALL WEBWORM,
Hyphantria cunea (Drury)

Importance. — The fall webworm is not considered an important forest pest. However, ugly webs can seriously detract from aesthetic values. The preferred hosts in the South are persimmon, pecan, and sourwood.

Identifying the Insect. — The adult moth has a wingspan of 1 (25 mm) to 1¼ (31 mm) inches and is snowy white, usually with dark spots on the wings. The larvae are 1 (25 mm) to 1¼ (31 mm) inches long and covered with silky hairs. The color varies from pale yellow to green, with a black stripe on the back and a yellow stripe on each side.

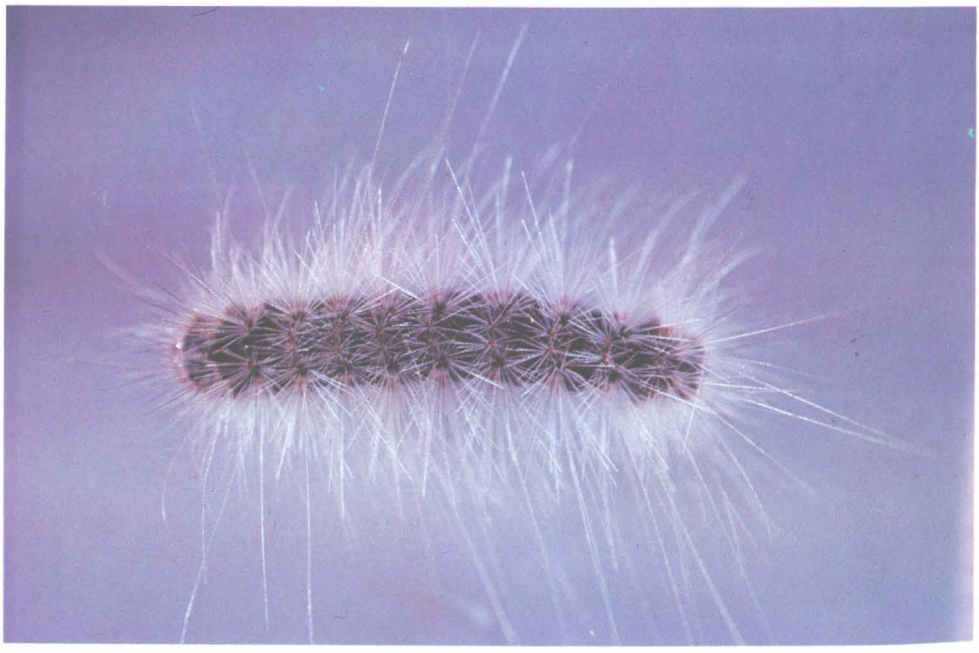
The pupae are found inside a gray cocoon constructed of silk, frass, and debris. The eggs are small, yellow, or light green, and turn gray before hatching.

Identifying the Injury. — Usually the first signs of attack are the large, silken web and skeletonized leaves. The silken web usually contains large numbers of caterpillars.

Biology. — The moths emerge in the spring. After mating, females lay eggs in masses (400 to 500) on the undersides of host leaves. The eggs hatch in approximately 2 weeks, and the larvae immediately begin to feed and construct webs. They enlarge the web as they continue to feed for 4 to 8 weeks. Then they spin a pupal cocoon in a sheltered place or in the duff or soil. There are at least two generations per year in the South.

Control. — Biotic agents, and unfavorable weather take their toll of these insects. Occasionally, chemical control may be necessary.

Typical damage showing large tents.



Larva.

FOREST TENT CATERPILLAR, *Malacosoma disstria* Hbn.

Importance. — Outbreaks occur periodically on oaks, tupelo gum, and other hardwoods over wide areas of the eastern half of North America. Growth loss and dieback occur, but trees are seldom killed unless they sustain 3 or more successive years of complete defoliation.

Identifying the Insect. — The larvae have pale bluish lines along the sides of a brownish body, and a row of keyhole-shaped white spots down the middle of the back. They are sparsely covered with whitish hairs, and reach 2 inches (50 mm) at maturity. Adult moths are buff-brown, with darker oblique bands on the wings. Egg masses of 100 to 350 eggs encircle the twigs and are covered with frothy, dark brown cement.

Identifying the Injury. — The first noticeable signs of attack are sparse crowns and falling frass. Caterpillars often cluster on the lower trunks of infested trees. Single trees or complete stands may be completely defoliated during the spring.

Biology. — Eggs hatch in early spring. Caterpillars feed for 4 to 6 weeks on the opening buds, foliage, and flowers. Despite its name, this species does not form tents. Pupation occurs in yellowish cocoons and lasts 10 to 14 days. Moths emerge from late May to July, mate, and deposit their eggs. There is one generation per year.

Control. — Natural control agents include insect parasites of eggs, larvae, and pupae. Predators and viruses and fungus diseases, as well as high and low temperatures, also kill forest tent caterpillars. Starvation is common when populations exceed the food supply. Several chemicals and a microbial insecticide are registered for control.

Larvae - note keyhole shapes on back.

Large areas are often defoliated.

GYPSY MOTH,
Lymantria dispar (Linnaeus)

Importance.—The gypsy moth, which came from France, is considered one of the most important pests of red and white oaks in the Northeast. It has spread southward into Virginia and is continuing to move south. Favored host species are oak, apple, alder, basswood, birch, poplar, sweetgum, willow, and hawthorn. Less favored are hickory, maple, cherry, cottonwood, elm, blackgum, larch, sassafras, and hornbean. Some mortality even occurs in white pine. It causes widespread defoliation, resulting in reduced growth, loss of vigor, mortality, and reduces aesthetic, recreational, and wildlife values. Gypsy moth larvae can be a serious nuisance in urban and recreation areas.

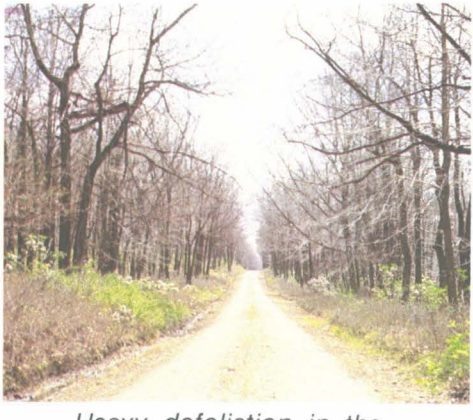
Identifying the Insect.—Older larvae are brownish-gray, with tufts of hair on each segment and a double row of five pairs of blue spots, followed by six pairs of red spots, on the back. Mature larvae are from 1½ to 2½ inches (40 to 60 mm) long. Adult male moths are dark brown, with wavy dark bands across the forewings. Females are white and cannot fly.

Identifying the Injury.—Young larvae chew small holes in leaves. Older larvae feed on leaf edges, consuming entire leaves except for the larger veins and the midribs. The entire tree is often defoliated.

Biology.—Larvae emerge in late April or early May from overwintering eggs and feed through June and into early July. Pupation occurs in sheltered places and lasts 2 weeks. Adults emerge in July and August. Females deposit egg masses (100 to 800 eggs) covered with buff-colored hairs, under rocks and on tree trunks, limbs, houses, picnic tables, trailers, campers, mobile homes, cars, and other sheltered places.

Control.—Natural controls, including introduced insect parasites and predators, virus diseases, and adverse weather conditions, help control the gypsy moth. Chemical and microbial insecticides have been used, primarily in urban and recreation areas, to prevent defoliation and the nuisance effects of the pest.

Larva.



Heavy defoliation in the middle of summer.

LOCUST LEAFMINER, *Odontata dorsalis* (Thunb.)

Importance.—Outbreaks of the locust leafminer are generally more spectacular than destructive. In combination with other stress factors, infestations can contribute to growth loss and even mortality. The major hosts are black locust and honeylocust. Other tree species (apple, beech, birch, cherry, elm, oak, and hawthorn) are occasionally attacked.

Identifying the Insect.—The adult is a small, elongated, flattish beetle, about ¼ inch (5 to 6 mm) in length. The head is black, and the thorax and most of the wing covers are orange. The full-grown larvae are yellowish, flat, and slightly larger than adults.

Identifying the Injury.—Adults skeletonize and eat holes in the leaves, whereas larvae mine the leaves (the latter damage is more destructive). Under outbreak conditions, whole hillsides turn gray or brown, often suggesting fall color change.

Biology.—Adults overwinter in bark crevices or in leaf litter and emerge about the time leaves begin to unfold in the spring.

Eggs are deposited on the undersides of locust leaflets. They overlap like shingles in groups of three to five and are cemented together by excrement. Upon hatching, the larvae first feed collectively in a common, blisterlike mine. Then, the larvae disperse, excavating their own individual mines. Pupation occurs within the translucent blisters in July. There are two generations annually.

Control.—Control of the locust leafminer is generally not necessary. When aesthetics are involved (such as in park, shade tree, or recreation situations), control might be justifiable.

Typical damage caused by larval mining.

ORANGESTRIPED OAKWORM,
Anisota senatoria (J. E. Smith)
and
PINKSTRIPED OAKWORM,
Anisota virginiensis (Drury)
and
SPINY OAKWORM,
Anisota stigma (Fabricus)

Importance. —These oakworms occur throughout the eastern United States. They are voracious feeders, and where abundant, quickly strip the trees of their foliage. Since defoliation takes place in late summer to fall, however, forest stands of white and red oak are generally able to survive with only minimal growth loss or crown dieback. The greatest damage is the aesthetic impact and nuisance the caterpillars create in urban areas.

Identifying the Insect. — The larvae of the orangestriped oakworm are black with eight narrow yellow stripes, the pinkstriped oakworm larvae are greenish brown with four pink stripes, and the spiny oakworm larvae are tawny and pinkish with short spines. Larvae are about 2 inches (50 mm) long and have a pair of long, curved "horns". The adult moths are a similar yellowish red, with a single white dot on each of the forewings.

Identifying the Injury. — Young larvae feed in groups, skeltonizing the leaf. Later they consume all but the main veins and usually defoliate one branch before moving onto another. Older larvae are less gregarious and can be found crawling on lawns and the sides of houses.

Biology. — Adult moths appear in June and July and deposit clusters of several hundred eggs on the underside of leaves. The eggs hatch within a week, and the larvae feed during July to September for 5 to 6 weeks. The pupae overwinter in the soil. The orangestriped and spiny oakworms have only one generation per year, while the pinkstriped oakworm has two generations.

Control. — Natural enemies generally prevent widespread defoliation. Chemical control may be needed for high value trees.

Orangestriped oakworm larva.

Pinkstriped oakworm larva.

Spiny oakworm larva.

POPLAR TENTMAKER,
Clostera inclusa (Hubner)

Importance. — The poplar tentmaker occurs in southern Canada and from New England to Georgia and Colorado. Endemic populations may defoliate small groups of poplar and willow, especially trees growing in the open. Epidemic populations may completely defoliate large cottonwood plantations. Complete defoliation twice during the same growing season will result in growth loss, crown dieback, and in some cases, tree mortality.

Identifying the Insect. — Full grown larvae are light brown to nearly black and up to $1\,^{3}/_{5}$ inches (42 mm) long. They have four light yellow lines on the back, and a bright yellow and several indistinct lines on each side. Adults are brownish gray, with three whitish lines crossing each forewing. The hindwings are crossed by a wavy band.

Identifying the Injury. — Newly hatched larvae skeletonize the leaf; older larvae devour all except the leaf stalk. Severe defoliation occurs during summer and early fall. Many one or two-leaf webbed tents hang from the branches.

Biology. — Moths appear from March through September and lay cream to pink colored eggs in clusters of 150 to 300 on the leaves. The larvae are gregarious and live in tents or webs constructed by pulling together the edges of one or more leaves and lining them with silk. They feed from May to October and pupate in loose cocoons. There are four generations per year in the South.

Control. — Natural controls include parasites of the pest's eggs and larvae. Predators and virus and fungus diseases also kill the poplar tentmaker. Two chemical insecticides are registered for control.

Larvae in tent.

Typical webbed leaf tents.

SLUG OAK SAWFLY,
Caliroa quercuscoccinae (Dyar)

Importance.—The slug oak sawfly is usually an endemic pest of red and white oaks. From 1974 to 1976, however, it was epidemic in Kentucky, Virginia, and Tennessee. This pest has been reported from Massachusetts through North Carolina, Kentucky, and Tennessee. Repeated defoliations reduce growth, vigor, mast crops, and kill some trees.

Identifying the Insect.—Larvae are slug-like, yellowish green, and shiny, with black heads and thoracic legs. They are ½ inch (12 mm) long, and feed in groups. The adult is a typical sawfly, about ¼ inch (6 mm) long and light brown.

Identifying the Injury.—Leaves are skeletonized. Larvae consume the lower surfaces of the leaves, making the leaf transparent and revealing a fine network of veins. Defoliation starts in the upper crown in early summer and progresses downward. By late summer, heavily infested trees may be completely defoliated or have a light-reddish appearance.

Biology.—Larvae overwinter in cocoons and pupate in the spring. Adults and larvae are present throughout the summer. Eggs are deposited in single rows of slits on the lower leaf surface along main veins. There are two to three generations per year.

Control.—Microbial diseases, parasites, and other natural enemies generally keep the slug oak sawfly in check. Insecticides may be needed on high value shade and ornamental trees.

Larva beginning to skeletonize leaf.

VARIABLE OAKLEAF CATERPILLAR,
Heterocampa manteo (Doubleday)

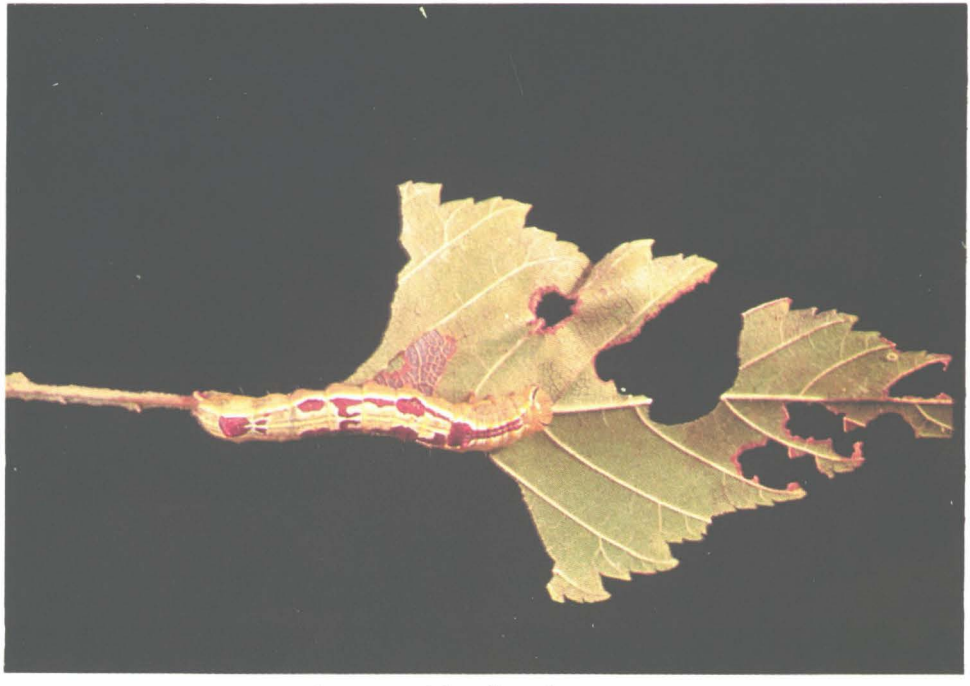
Importance. — This defoliator is common throughout eastern North America. It attacks a wide variety of hardwoods, including all species of oaks, but prefers the white oaks. Some infestations have covered millions of acres, retarding tree growth and reducing vigor. Outbreaks occur periodically and usually subside after 2 to 3 years, before serious tree mortality occurs.

Identifying the Insect. — The larval color is variable, but is generally yellowish green, with a narrow white stripe down the center of the back, and one or two yellowish stripes on the sides. The head is amber, with one dark and one light band on each side of the head. Mature larvae may reach 1 ½ inches (37 mm) long. The adult moth is ashy gray, with three dark wavy lines across each forewing. The wingspan is approximately 1 ½ inches (37 mm).

Identifying the Injury. — Young larvae skeltonize the leaf, while older larvae devour the entire leaf except the leaf stalks and main veins. There are two periods of defoliation — early May to late June and mid-August to late September.

Biology. — There are two generations in the South and one generation in the North. In the South, the larvae feed from early May until late June and pupate in the soil. Second generation larvae feed from mid-August until late September, then move to the ground to spin cocoons and over winter. Adult moths emerge from cocoons by early spring.

Control. — Insect parasites and predators destroy eggs, larvae, and pupae. Winter mortality also helps keep most infestations in check. Chemical control is occasionally needed to protect high value trees.



Larva and feeding damage.

WALKINGSTICK,
Diapheromera femorata (Say)

Importance.—The walkingstick attacks oaks and other hardwoods. In the South, severe outbreaks have only occurred in the Ouachita Mountains of Arkansas and Oklahoma. Branches are killed or die back in heavily defoliated stands, but continuous defoliation for several years can result in mortality. The insects create a nuisance in high use areas such as parks and recreation sites.

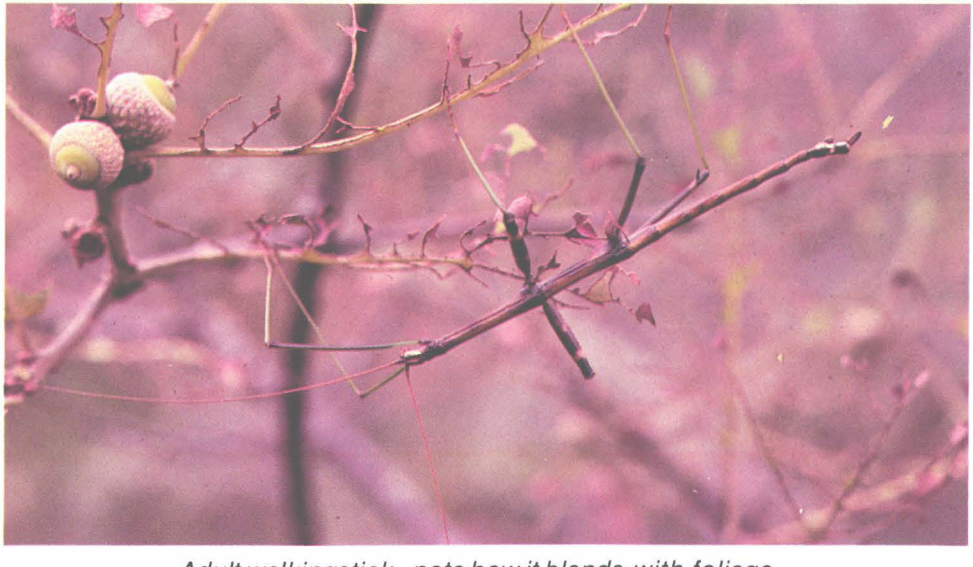
Identifying the Insect.—Nymphs and adults are slender and have long thin legs and antennae. While motionless, they closely resemble their host. Adults are about 2½ to 3 inches (62 to 76 mm) long, and their body color varies from brown to green to multicolors of gray, green, and red.

Identifying the Injury.—The entire leaf blade, except the base of the stout veins, is eaten. During heavy outbreaks, large stands are often completely denuded. Trees may be defoliated twice during the same season. Because the walkingstick does not fly, infestations are often localized and spread only a few hundred yards during the season.

Biology.—Overwintering eggs in leaf litter hatch in May and June. Nymphs become adults during the summer and fall. Females deposit up to 150 eggs, which are randomly dropped to the forest floor. There is one generation per year in the South, while 2 years are required farther North.

Control.—Natural enemies, particularly birds, are often effective. Chemical control is occasionally warranted in high use areas.

Patches of heavy defoliation.



Adult walkingstick - note how it blends with foliage.

WALNUT CATERPILLAR,
Datana integerrima,
Grote and Robinson

Importance.—The walnut caterpillar feeds only on black walnut, pecan, hickory, and butternut. Defoliation may weaken the tree and make it susceptible to damage by wood borers. Tree mortality is rare, but may occur after 2 years of heavy defoliation.

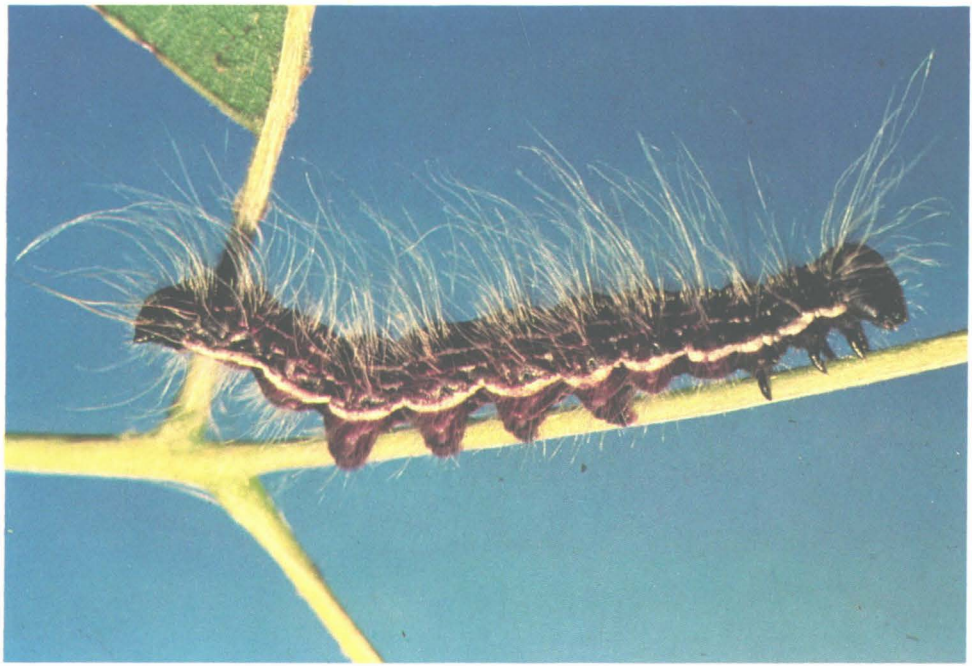
Identifying the Insect.—Eggs are spherical and pale green with white caps. They are laid in clusters of 120 to 800 on the underside of leaves. All larvae have black heads. Newly hatched larvae are light green and change to reddish brown with white stripes. Fully grown larvae are nearly black with white hairs. They are 1 to 2 inches (25 to 50 mm) long.

Pupae are ¾ inch (20 mm) long and shiny, dark, reddish brown. The wing-span of moths is about 1¾ inches (45 mm). The front wings are dark tan with four rust colored lines. The hind wings are light tan.

Identifying the Injury.—Young larvae skeletonize the upper leaf surface. As they grow, they feed on the entire leaf except the petiole. Individual branches, entire trees, or groups of trees may be completely defoliated.

Biology.—Moths emerge in May and lay eggs. Eggs hatch in 8 to 10 days, and larvae feed until mature and pupate in the soil. Adults emerge in July and begin the second generation, which is the largest and most destructive. Larvae cluster together on tree branches or trunks and molt simultaneously, leaving a large mass of hairy cast skins adhering to the bark.

Control.—Parasites, predators, and diseases are major factors influencing population levels. Cultural controls are: clipping foliage to destroy egg masses and larvae, removing clustered larvae as they gather to molt, and destroying pupae by shallowly disking the soil after larvae have pupated. Chemical control is usually not necessary because tree mortality is rare.



Larva.

WHITEMARKED TUSSOCK MOTH,
Hemerocampa leucostigma
(J. E. Smith)

Importance.—In the South, the whitemarked tussock moth occasionally occurs in epidemic numbers and heavily defoliates several species of hardwood, primarily live oak, water oak, red oak, and white oak. It is not considered a serious forest pest; however, it causes considerable damage to shade and ornamental trees. Trees are seldom killed, but growth loss does occur. Larvae often create a nuisance in urban and recreation areas due to dropping frass, their allergenic hairs, and their migratory habits.

Identifying the Insect.—The larva is 1 to 1½ inches (25 to 38 mm) long. It has a bright red head with a yellowish body, a pair of upright pencil tufts of black hairs on the prothorax, and four white to yellowish brushlike tufts of hairs on the back toward the head. The adult male moth is gray brown, with darker wavy bands and a white spot. The female is wingless and whitish gray.

Identifying the Injury.—Young larvae chew small holes in leaves. Older larvae feed on leaf edges, consuming entire leaves, except for larger veins and midribs. Entire trees may be defoliated.

Biology.—Overwintering occurs in the egg stage. Eggs are laid in small, white masses and hatch in the early spring. Larvae feed until they pupate in May or June. Pupation occurs in a cocoon, and adults emerge in about 2 weeks. Adults live 2 to 4 weeks. In the South there may be as many as three generations per year. The female adult emerges from a beige cocoon and mates, laying her eggs in a mass on her cocoon.

Control.—Parasites, predators, microbial diseases, starvation, and unfavorable weather normally bring epidemics under control. Control is not necessary under forest conditions. In urban and recreation areas, insecticides may be desirable to avoid defoliation, the nuisance effect of this pest, and the allergenic effect of the larval hairs.

Larva.

YELLOWNECKED CATERPILLAR, *Datana ministra* (Drury)

Importance.—This caterpillar is a defoliator of oaks and many other hardwoods throughout the United States. Infestations have been most common in the Appalachian and Ozark Mountains and their foothills. Damage is more severe among shade and ornamental trees than forest stands.

Identifying the Insect.—The larvae are yellowish and black striped, and moderately covered with fine, white hairs. The head is jet black. The segment behind the head is bright orange-yellow—hence, its name, yellownecked caterpillar. Full-grown larvae are about 2 inches (50 mm) long. When disturbed, the larvae lift their heads and tails in a distinctive U-shape. This is a defensive measure to prevent parasitism by various wasps and flies.

Identifying the Injury.—Newly hatched larvae skeltonize the leaf; older larvae devour all except the leaf stalk. Individual trees, or even stands, may be defoliated during late summer and early fall. Since defoliation is confined to the late part of the growing season, little damage is caused to the tree.

Biology.—Moths appear during June and July and deposit white eggs in masses of 50 to 100 on the undersides of the leaves. Larvae feed in groups, maturing in August and September. Mature larvae drop to the soil and pupate at depths of 2 to 4 inches (50 to 100 mm), where they spend the winter. There is one generation per year.

Control.—Natural enemies generally keep infestations in check. Chemical controls are occasionally needed.

Larva.

CARPENTERWORM,
Prionoxystus robiniae (Peck)

Importance.—In eastern and southern states, oaks—particularly red oaks—are the most heavily damaged. Other hosts are green ash, black locust, elm, maple, willow, cottonwood, and sometimes fruit trees and ornamental shrubs. The damage—wormholes—causes unsightly scars on ornamental trees and degrade, estimated at 15 percent of the value of rough sawn lumber.

Identifying the Insect.—Newly hatched larvae are ¼ inch (6 mm) long and reddish pink. They gradually become greenish white and are 2 to 3 inches (50 to 75 mm) long at maturity. Brown pupal skins protruding from entrance holes are common in early summer. Adults are grayish, stout-bodied moths. The hindwing in the male has an orange spot.

Identifying the Injury—Earliest signs of attack are sap spots on the trunk. Later, frass is ejected from entrance holes. Burrows 2 inches (50 mm) in diameter under the bark, and galleries ½ inch (12 mm) in diameter and 5 to 8 inches (12 to 22 cm) long in the wood are typical. Galleries are open or loosely plugged with frass. Holes in lumber are dark stained.

Biology.—Adult moths appear in April to June and deposit 400 to 800 eggs in bark crevices. Eggs hatch in 10 to 12 days, and young larvae tunnel into the bark and wood. Pupation occurs within the gallery during spring and lasts 3 weeks. A life cycle requires 1 to 2 years in the South, and 2 to 4 years in the North.

Control.—Management practices such as maintaining high tree vigor, removing brood trees, preventing bark injuries, and spraying the trunk or fumigating the galleries with insecticides help to minimize damage.

Attacks on the trunk.

Larva in a typical gallery in the wood.

COLUMBIAN TIMBER BEETLE, *Corthylus columbianus* (Hopkins)

Importance.—This beetle occurs over much of the East and south to Georgia and Arkansas. It attacks oaks (particularly red oaks), maples, birch, basswood, sycamore, yellow poplar, and elm, damaging the trunks of live trees of all sizes. Damaged wood cannot be used for veneer, cooperage, and furniture.

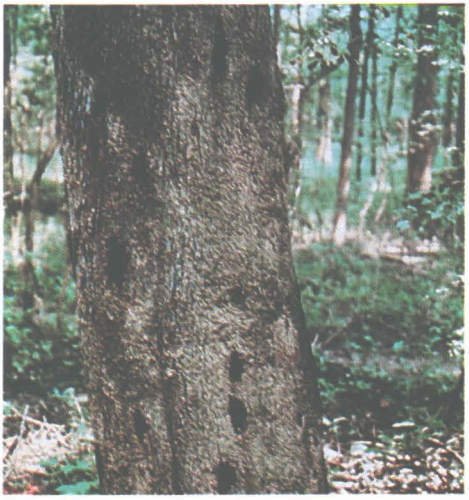
Identifying the Insect.—Adults are black to reddish-brown cylindrical beetles about 1/5 inch (4 mm) long. The larvae are white, legless and C-shaped.

Identifying the Injury.—Holes less than 1/10 inch (2 mm) in diameter are bored straight into the sapwood until the tunnel nears the heartwood, turning right or left. Damage is conspicuous in log ends. Streaks of stain originating from the tunnels are called flagworm defects.

Biology.—Adult beetles construct galleries. Eggs are laid in chambers along the main tunnel where the larvae live and develop. Larval food is a white fungus that grows on the gallery walls. There are two to three generations per year.

Control.—There is no apparent relationship between tree vigor and susceptiblity. No natural enemies have been found. Protection of veneer-quality trees with insecticides should be considered.

Pupae and adult.



Staining on bark at point of attack.

COTTONWOOD BORER,
Plectrodera scalator (Fab.)

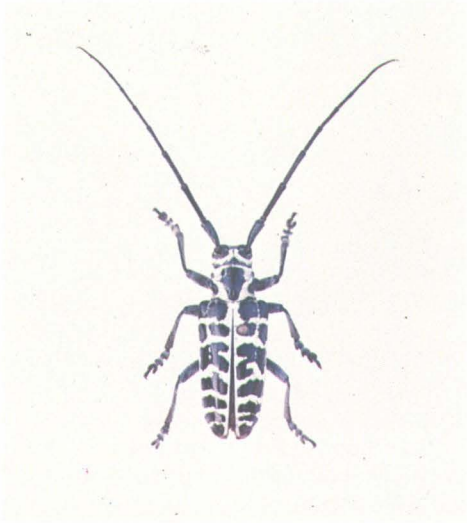
Importance.—The cottonwood borer ranges throughout the eastern Unites States, but highest populations and greatest damage occur in the South. It attacks cottonwood and willow. Trees weakened by severe infestations may be broken off by wind. Damage is sometime serious in cottonwood nurseries, natural stands, and plantations, particularly those planted offsite.

Identifying the Insect.—Adult beetles are 1 to $1^1/_5$ inches (25 to 38 mm) long and about ½ inch (12 mm) wide. They are black with lines of cream-colored hair forming irregular black patches. Larvae are seldom seen.

Identifying the Injury.—The adults may cause serious damage in cottonwood nurseries by feeding on the tender shoots of young trees, causing them to shrivel and break off. The larvae bore into the inner bark and wood at the root collar and tunnel downward into the roots. Light brown, fibrous frass is sometimes ejected from bark openings at or slightly above the ground line, accumulating in piles at the base of the tree. The root collar and roots of infested trees may be riddled by larval tunnels.

Biology.—The adults appear in midsummer. After feeding briefly, they descend to the bases of host trees where the famale deposits her eggs in small pits gnawed in the bark. Eggs hatch in 16 to 18 days. The larvae bore downward in the inner bark, entering a large root by autumn. Pupation occurs in the gallery from April to June and lasts about 3 weeks. The new adults chew exit holes through the sides of the pupal chambers and emerge through the soil. Some larvae complete development in 1 year, while others require 2 years.

Control.—Management practices—such as locating new nurseries away from infested trees, planting uninfested cuttings, and removing and destroying infested rootstock—help to minimize damage. Three weekly applications of insecticide, timed to begin soon after emergence, have given good control of adult beetles in nurseries.



Adult.

Larvae in a root.

COTTONWOOD TWIG BORER, *Gypsonoma haimbachiana* (Kft.)

Importance.—The cottonwood twig borer is widely distributed throughout the eastern United States, from Canada to the Gulf states and west to Missouri. It is one of the most destructive insects of young cottonwood. Other poplars are also hosts. Terminal shoot injuries cause serious stunting, forks, crooks, and other malformations. This leads to reduction in the quality and quantity of merchantable pulpwood, sawlogs, or veneer.

Identifying the Insect.—The adult is ash gray and has wingspread of ½ to 7/10 inch (13 to 17 mm). The basal portion of the forewing is darker than the apical. Full-grown larvae are pale, with a brown-yellow head. They are from 2/5 to ½ inch (10 to 13 mm long).

Identifying the Injury.—Larvae bore into the terminals and branch ends of the host. They frequently kill the bud and up to 10 inches (25 cm) of the terminal. Often the old dead terminal remains intact on the tree for several months after the larvae have emerged. A stunted, deformed, limby tree is a good indication of cottonwood twig borer damage.

Biology.—The female moth lays eggs on the upper surface of leaves along the midrib, alone or in groups of two to eight. Hatching occurs in about 5 days. The young larvae cover themselves with silk mixed with trash, then bore into the midrib. After about 3 days the larvae abandons their midrib galleries and move to tender shoots where they tunnel in and complete their larval development. Larvae reach maturity in about 21 to 23 days and move down the trunk, where they spin cocoons in sheltered bark crevices or litter or between leaf folds. Adult moths emerge in 8 or 9 days. It takes from 40 to 45 days to complete the life cycle in midsummer. There are four or more generations per year in the South.

Damage on cottonwood.

Control.—The most effective natural control is a potter wasp, which tears open tender cottonwood shoots and removes twig borer larvae from their galleries. Other wasps also parasitize twig borer larvae. Direct control can be obtained through the use of soil-applied systemic insecticdes.

HICKORY BARK BEETLE,
Scolytus quadrispinosus Say

Importance.—The hickory bark beetle is reported to be the most serious insect pest of hickory in the United States. Several states have reported instances where thousands of trees were killed. Pecan and butternut are also hosts.

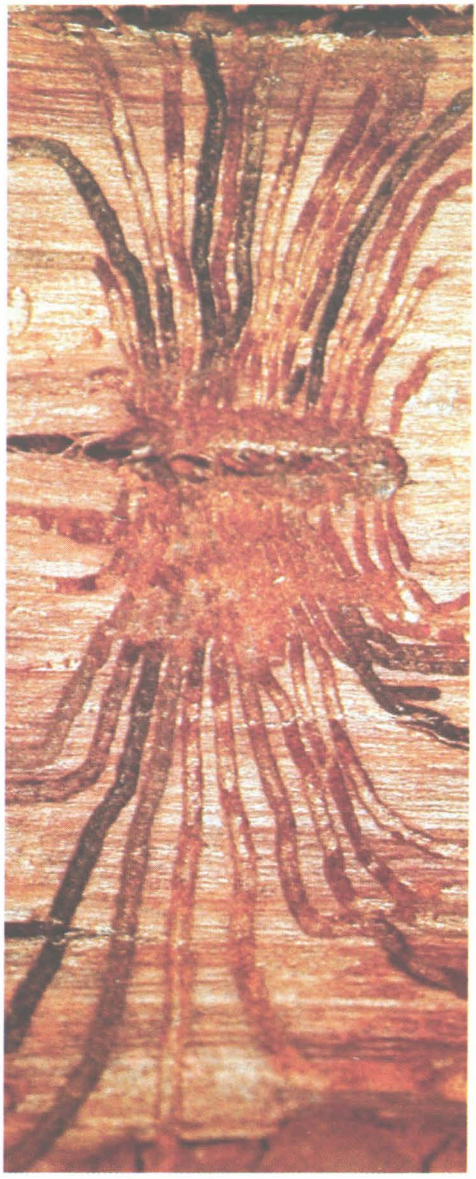
Identifying the Insect.—The adult is short, stout, black, almost hairless, and 1/5 inch (5 mm) long. The underside of the posterior is concave and has spines. The larvae are typically white or cream-colored, legless grubs, about the same size as the adults.

Identifying the Injury.—Dying leaves and twigs and trees with red foliage are the first eveidence of attack. Short, vertical egg galleries with radiating larval galleries etched in the sapwood are good indicators of damage.

Biology.—Adults appear in early summer and feed for a short time at the bases of leaf petioles and on twigs before attacking the trunks.

Twenty to 60 eggs are deposited in egg galleries in the phloem. When nearly full-grown, the larvae gradually angle away from the adult gallery. Before reaching maturity, they leave the phloem to pupate in the bark. Winter is spent in the larval stage and pupation occurs in the spring. There are usually two generations each year in the southern United States.

Control.—Control practices include felling infested trees over large areas and destroying the bark during winter months or storing infested logs in ponds. Insecticides can also be used.



Egg gallery and larval mines.

LOCUST BORER,
Megacyllene robiniae (Forster)

Importance.—This is the most serious insect pest of black locust. It provides infection courts for the fungus, *Fomes rimosus,* which causes substantial defect, growth loss, and some mortality. The only host is black locust.

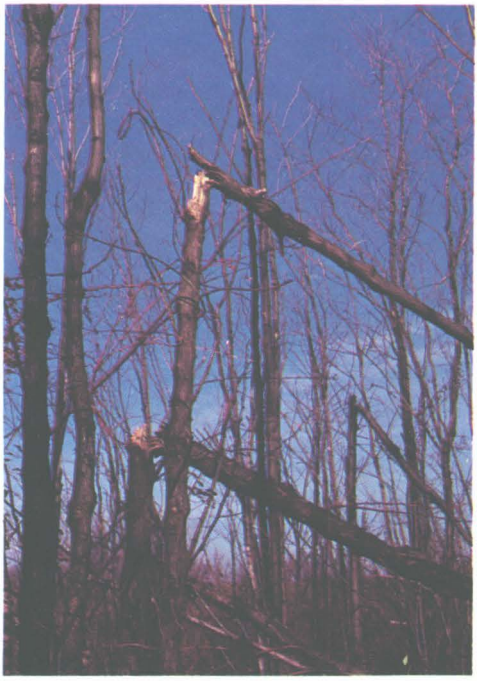
Identifying the Insect.—The adult is an attractive longhorned beetle, often seen feeding on goldenrod in late summer and early fall. It has bright yellow bands expanding across a jet black thorax and wing covers, and the third band on the wings forms a "W" design. Legs are yellow-orange and long. Full-grown larvae are full-bodied, pale, and about 1 inch (25 mm) long.

Identifying the Injury.—The first sign of attack occurs in the spring, around the time of bud burst. Oozing sap at the point where the larva bores into the tree causes a wet spot on the bark. Eventually, the larva begins to tunnel into the wood, pushing granular frass out of the entry hole.

Wood infested by locust borers can be virtually "honeycombed" by the larvae. Sometimes stems are so weakened that they become windbroken.

Biology.—Eggs are deposited in rough bark surfaces and around wounds of living trees. Newly-hatched larvae excavate a small hibernating cell in the inner bark and overwinter. In the spring, they bore into the wood, enlarging the tunnel to the exterior. About mid-July, they emerge at the original attack point. There is one generation annually.

Control.—Since the heaviest attacks occur in stressed trees, most preventive recommendations are designed to encourage or maintain health and vigor. This includes planting superior trees, avoiding pure locust stands, and removing low vigor and overmature trees. Excluding damaging livestock from black locust stands can also reduce beetle attacks.



Damage caused by borers and wind.

Adult.

RED OAK BORER,
Enaphalodes rufulus (Haldeman)

Importance.—This is a major pest of red oaks, accounting for millions of dollars in losses from defects and degrade in lumber. Valuable shade trees in parks and cities are sometimes attacked, but are rarely killed.

Identifying the Insect.—Adult borers are longhorned beetles. Their antennae are very long, almost doubling their 1-inch (25 mm) body length. Their rust brown color blends well with the bark surface, and they are rarely seen. The pale, robust larvae have very small legs on the thorax.

Identifying the Injury.—The first signs of attack resemble the fine frass produced by ambrosia beetles. As the larvae bore into the tree, sap begins to extrude from the attack points. Within the tree, tunnel diameters gradually increase from pinhole size to about ½ inch (12 mm) in diameter as larvae grow. Tunnels are 6 to 10 inches (15 to 25 cm) long and are often accompanied by discolored and decaying wood. They are usually within 6 inches (15 cm) of the pith.

Biology.—The red oak borer has a 2-year life cycle. Eggs are laid in midsummer in roughened areas or near wounds, and larvae tunnel under the bark for the first year. In the second year, the more damaging wood tunneling commences. Prior to pupation, the larvae chew round exit holes through which they later emerge as adults.

Control.—Removal of brood trees significantly reduces the pest population. Measures aimed at encouraging stand vigor will discourage attack. Infested, high value shade trees may be treated with insecticides.

Adult.

SMALLER EUROPEAN ELM BARK BEETLE, *Scolytus multistriatus* (Marsham)

Importance.—This beetle is the prime vector of the Dutch elm disease fungus which has destroyed millions of American elms since its introduction into the United States. The beetle attacks all native and introduced species of elms.

Identifying the Insect.—Adults are reddish-brown beetles about ¼ inch (3 mm) long. The underside of the posterior is concave and armed with a prominent projection or spine on the undersurface of the abdomen. The larvae are typical, white or cream-colored, legless grubs, about the same size as adults.

Identifying the Injury.—Beetles excavate a 1 to 2 inch (25 to 50 mm) straight egg gallery parallel with the wood grain. Larval mines are roughly perpendicular to the egg gallery. The result is a design resembling a long-legged centipede on the inner bark and wood surface.

Symptoms of the disease are described under "Dutch Elm Disease" in this booklet.

Biology.—Smaller European elm bark beetles overwinter as larvae under the bark and develop into adults in the spring, emerging after the leaves expand. Adults feed at twig crotches of healthy elms, infecting the tree with Dutch elm disease. Then they fly on to other elms for breeding. These attacked trees have usually been weakened by drought, disease, or other stress factors.

After boring through the bark, the beetles excavate their egg galleries, grooving the inner bark and wood surface in the process. When larvae are full-grown, they construct pupal cells at the end of their larval mines. New adults emerge by boring directly through the bark, leaving it peppered with tiny "shot holes." There are two generations annually.

Control.—The most effective method of reducing losses is probably through removal of dead and dying elms and the pruning of dead and dying limbs. Several chemical insecticides may be applied as preventative sprays or to kill beetles before they spread to uninfested trees.

Beetle feeding at twig crotch.

TWOLINED CHESTNUT BORER, *Agrilus bilineatus* (Weber)

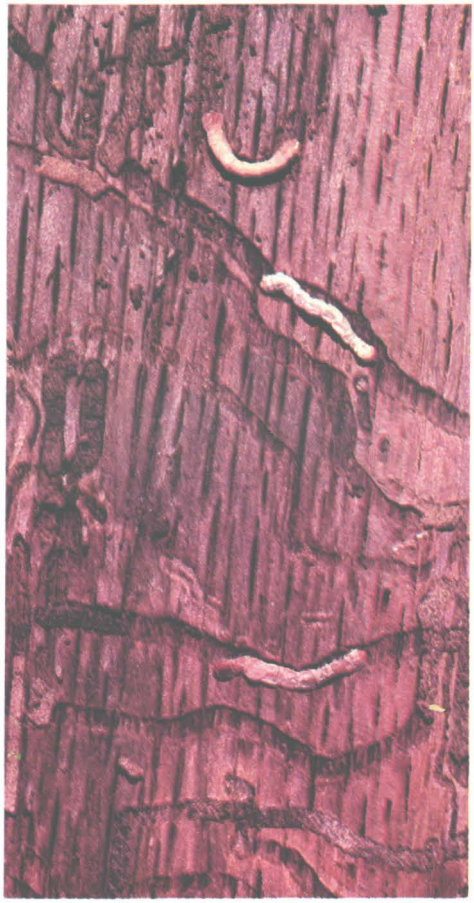
Importance.—This borer attacks red and white oaks throughout the East. Trees weakened by drought, insect defoliation, or other factors are most susceptible. Larvae mine the cambium, resulting in girdled trees. Mortality can be extensive in weakened stands.

Identifying the Insect.—Adult beetles are about 1/5 to ½ inch (6 to 12 mm) long, slender, and black, with a light yellowish stripe on each wing cover. Larvae are white, slender, flattened, and about 1 inch (25 mm) long, with two spines at the rear end.

Identifying the Injury.—Larvae excavate winding mines in the inner bark and outer sapwood of the main trunk and large branches, frequently girdling the tree. Attacks usually begin in the upper tree canopy and extend downward as the tree continues to weaken. D-shaped adult emergence holes are evidence of infestation.

Biology.—Adults emerge during spring and early summer and deposit eggs in bark crevices. Eggs hatch in 10 to 14 days. The larvae burrow through the bark and cambium. They overwinter in cells in the bark and pupate the follwing spring. There is one generation per year.

Control.—Control is mainly a matter of preventing attacks through cultural practices that promote tree vigor. Spraying to protect foliage from insect defoliators is recommended in some areas.



Larvae in galleries.

WHITE OAK BORER,
Goes tigrinus (DeGeer)

Importance.—This is one of the most destructive borers of the white oak group in the South. Its importance is compounded by the increasingly higher prices of veneer-quality lumber.

Identifying the Insect.—The adult long-horned beetles are rarely seen. They are mottled brown and white, about 1 inch (25 mm) long, with a spine on each side of the thorax and antennae about as long as the body. Larvae are grub-like, pale yellow, robust, and up to 1½ inches (37 mm) long.

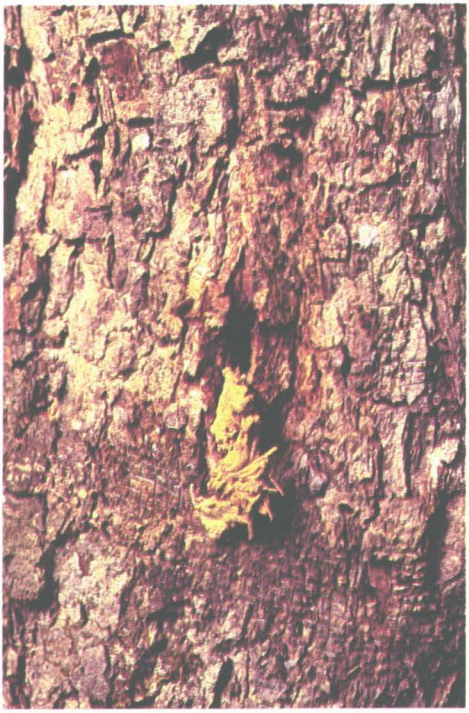
Identifying the Injury.—Oozing of sap and frass production on trunks are the most prominent indications of infestations. The sap often attracts flies, bees, wasps, butterflies, and other insects. Internal damage consists of extensive larval mining, often accompanied by discoloration and subsequent decay of the wood.

Biology.—Adults emerge in mid-spring and deposit eggs in roughened bark or near wounds. About 3 weeks later, eggs hatch, and larvae tunnel directly into the wood. New adults develop within the tunnels and emerge through a new, circular exit hole. The life cycle requires 3 to 5 years for completion.

Control.—Removal of heavily infested brood trees, combined with measures designed to encourage tree vigor, are the most practical controls. Woodpeckers and sap ooze are the most important natural controls.

Removing vines, which are good egg laying sites, may be cost effective when the wood is used for veneer. Vine removal operations should not damage bark, since this can actually encourage infestations.

Adult



Typical attack on white oak.

APHIDS

Importance. — Aphids infest hardwoods and conifers throughout the United States. They can be found almost anywhere on a tree, particularly on new growth. Heavy infestations distort foliage, cause terminal dieback, reduce tree vitality, weaken the tree, and cause branch and crown dieback. In young trees and seedlings, mortality can occur from heavy infestations. Aphids are usually of greatest concern in nurseries, seed orchards, and shade and ornamental trees. Honeydew and sooty mold, associated with aphids, usually mar the beauty of ornamentals.

Identifying the Insect. — Aphids vary in bodycovering and range in size from 1/50 to ¼ inch (½ to 6 mm) long. However, they are all soft-bodied insects. Most aphids are pear-shaped, with a pair of cornicles at the posterior of the abdomen. They may be transparent, yellow, green, pink, brown, almost black, or spotted. Some may be covered with a white woolly wax. Some are winged, while others are not.

Identifying the Injury. — Aphids feed on various parts of a tree. Some feed on the undersides of leaves, causing stunting, curls, and folds in the leaves. Other symptoms to look for are: leaf discoloration; dieback or "flagging" of newly formed terminals, branch ends, and new leaves; early leaf drop; and ringlike swellings or knots at nodes and buds. Trees with poor vigor or with branch and crown dieback should be examined closely for aphids. Sooty mold and ants frequenting a tree are good indicators of an active or recent aphid attack.

Biology. — Overwintering can occur in any life stage, but the most common is the adult or egg. Eggs hatch and live births usually occur in the spring, and nymphs begin feeding on selected parts of the plant. Some aphids migrate as nymphs; others spend their life in one place. Some aphids have only one generation per year; other have several. Some aphids require alternate hosts in alternate generations.

Control. — Parasites and predators are effective in controlling aphid outbreaks and maintaining low populations. However, insecticides are often used to protect high value trees and are most effective against the nymphs.

Typical soft-bodied aphid on pine.

LACE BUGS,
Corythucha spp.

Importance.—Adults and nymphs of lace bugs feed on the leaves of many species of hardwoods throughout the South. Some of the more common species affected are sycamore, oak, elm, hackberry, and basswood. By the end of August, leaves attacked by these insects may be discolored and perform little photosynthesis, and may even fall from the tree.

Identifying the Insect.—Nymphs are usually dark colored and covered with spines. Adults have broad, transparent, lacelike wingcovers. They are flattened, and about ¼ inch (6 mm) long. Some species are beautifully colored.

Identifying the Injury.—Infested leaves have chlorotic flecks or tiny chlorotic spots on the upper side. Heavily infested trees may be partially or full defoliated, especially during dry weather.

Biology.—Adults overwinter in bark crevices and similar protected areas of their host. The adults become active during the spring and lay eggs on the underside of leaves. After the eggs hatch, the nymphs begin feeding on the underside leaves. They feed by inserting their mouth parts into leaf tissue and sucking the plant juices. A complete life cycle, from egg to adult, may take in 30 to 45 days; several generations may occur each year. In late summer, both adults and nymphs will be feeding at the same time.

Control.—Natural enemies are usually effective in maintaining populations at a low level and bringing outbreaks under control. Chemical controls are usually only used on shade and ornamental trees.

Adults on sycamore.

SCALES

Importance. — Many different types of scales effect hardwoods and conifers throughout the United States. A large scale population can reduce growth, weaken the tree, and cause branch or crown dieback. Scales are usually of greatest concern in nursery stock, seed orchards, and shade and ornamental trees. Honeydew and sooty mold, associated with scales, usually mar the beauty of ornamentals.

Identifying the Insect. — Scale insects vary in shape and form. There are soft-bodied, hard-bodied or armored scales. They may resemble a small turtle or oyster shell or even part of the bark of the tree. Some scales are white and very obvious; others are dull and perfectly match their host's color. Therefore, close examination is very important. They can range from $^{1}/_{50}$ to $^{3}/_{10}$ inch (½ to 7 mm) in length. Scale insects can be found on any part of a tree.

Identifying the Injury. — Trees with poor vigor or with branch and crown dieback should be examined closely for scales. Scale feeding may cause some abnormal plant growth at the point of attack, such as stunting of leaf or shoot growth, leaves turning yellow or red, and branch gouting. Other symptoms to look for are early leaf drop or dieback or "flagging" of newly formed terminals, branch ends, and new leaves. Ringlike swellings or pits in the bark cause a rough appearance of branches. Heavy infestations will kill trees. Sooty mold and ants frequenting a tree are good indicators of scale infestations.

Biology. — Eggs are usually produced underneath the female scale in the spring. The eggs hatch, and the nymphs seek feeding sites. Some nymphs migrate to different sites to overwinter; others spend their complete life in one place. Some scales have only one generation per year; others have numerous generations.

Control. — Parasites and predators are effective in controlling infestations. However, insecticides are often used to protect high value trees and are most effective against immature scales.

Pine tortoise shell scale (soft).

Pine needle scale (armored).

BAGWORM,
Thyridopteryx ephemeraeformis
(Haworth)

Importance. — Bagworms are one of the most important pests of evergreen ornamentals in the South. Arbovitae and juniper are particularly susceptible. If infestations are heavy enough, they will strip evergreen shrubs of their foliage and cause branch dieback or death. Some hardwood species—such as maple, oak, dogwood, and willow—also are attacked, but rarely are they damaged as severely as conifers.

Identifying the Insect. — Bagworms are larvae and are rarely seen outside the bags they construct. The wingless female moth is grub-like and remains inside this tough, silken bag her entire life. Males are nimble fliers, and in the fall can be seen circling around infested trees in search of a mate.

Identifying the Injury. — Bagworms consume the entire needle or leaf, leaving only the needle sheath or mid-rib. They usually feed on one branch at a time. An indication of damage is the presence of bags suspended from twigs and branches.

Biology. — Bagworms overwinter as eggs, inside the bag that contained the female. In the spring, the eggs hatch and the larvae crawl out in search of food. By using silk and bits of needles, bar, or twigs, they construct a bag around themselves. When fully grown, the bags are between 1½ to 2½ inches (40 to 65 mm) in length and the larvae permanently suspend their bags from twigs and pupate. In the fall, the male moth emerges, flies to a female's bag, and mates. The female lays between 500 and 1,000 eggs within her bag. There is one generation annually.

Control. — In most cases, bagworm outbreaks are quickly reduced by low winter temperatures and a complex of several parasites. On ornamentals around the home, it is often practical to control bagworms by picking and destroying the bags. Chemical control is also effective.

Typical bags.

BLACKHEADED PINE SAWFLY, *Neodiprion excitans* Rohwer

Importance.—This sawfly, which ranges from Virginia to Texas, prefers loblolly and shortleaf pines but also feeds on slash, longleaf, and pond pines. Because heaviest defoliation occurs during late summer and fall, trees may go through the winter stripped of their needles. The resulting loss in vigor may predispose slow-growing pines to bark beetle attack.

Identifying the Insect.—Older larvae are about 1 inch (25 mm) long and olive green with a glossy black head. Two longitudinal black stripes run along the top of the body, and a conspicuous row of black spots occurs on each side. The adult female is about ½ inch (12 mm) long with a light brown body. She lays her eggs singly at the bases of needles on the tips of shoots.

Identifying the Injury.—Defoliation during spring and summer is not serious because larvae tend to feed on the older foliage. In the fall, however, defoliation may exceed 90 percent of the total crown and result in a considerable growth reduction during the following season. Heavily defoliated trees, especially overmature sawtimber, may be killed following secondary attacks by bark beetles.

Biology.—The larvae overwinter in light brown cocoons spun principally in duff, topsoil, and bark crevices at the base of the trees. Pupation is completed in the spring, and both adults and larvae are sometimes present throughout the summer and fall. There are 3 to 4 generations per year in the Gulf coastal region.

Control.—Outbreaks of the blackheaded pine sawfly occur periodically and usually subside rapidly. Natural enemies are usually helpful in preventing or ending outbreaks. Insecticides may be warranted on high value trees.

Larvae.

INTRODUCED PINE SAWFLY, *Diprion similis* (Hartig)

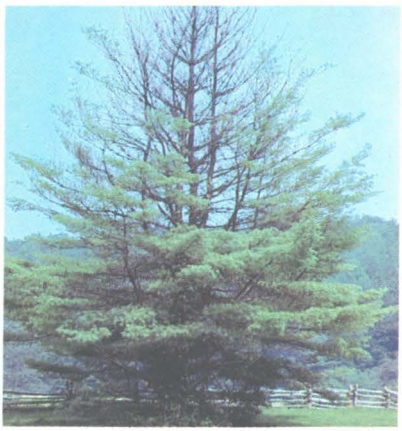
Importance. — The introduced pine sawfly occurs from Canada to North Carolina, and in the central and lake states. Eastern white pine is its favored host, but it also attacks Scotch, red, jack, and Swiss mountain pines. Infestations of this insect can be very serious in young plantations of white pine grown for timber products or Christmas trees.

Identifying the Insect. — A full-grown larva is about 1 inch (25 mm) long, with a shiny, black head. The body has a black stripe on the back and numerous yellow and white spots on the sides. Larvae spin light brown, tough, leathery cocoons on the host tree, other vegetation, and ground litter. Adults resemble flies and are about $^{3}/_{10}$ inch (8 mm) long and have four transparent wings.

Identifying the Injury. — Defoliation first occurs in the upper crown, giving it a thin appearance. First generation larvae feed on old needles, and later generations feed on both old and new needles, and sometimes on the bark of twigs. Trees in the most exposed locations and in the overstory suffer the most defoliation. Repeated heavy defoliation can cause branch and even tree mortality.

Biology. — In the southern Appalachians, first generation adults emerge in early spring, about April. Eggs are laid in rows in the needles and covered with a light green substance. Hatch occurs in about 14 days. Larvae feed until cocoons are spun in late June through July. Second generation adults emerge in late July, and most larvae have finished feeding and spin cocoons by late September. There are two generations and sometimes a partial third. As a result of overlapping generations, all life stages can be observed in midsummer.

Control. — Introduced and natural enemies play an important role in control of the introduced pine sawfly. Chemical insecticides are effective in protecting ornamental plantings and Christmas tree plantations from defoliation.



Typical damage on white pine.

Larva.

LOBLOLLY PINE SAWFLY, *Neodiprion taedae linearis* Ross

Importance. — This species is one of the most important defoliators of loblolly and shortleaf pine in the south-central states. In heavily infested areas, trees may be completely defoliated in the spring before new shoots have developed. Periodic outbreaks over large areas cause substantial growth loss and reduced tree vigor, but mortality rarely occurs.

Identifying the Insect. — Larvae are dull green in color, with black stripes along each side and often two lighter stripes below the heavy ones. They are about 1 inch (25 mm) in length, with brown heads. The adult female has a brown body with black markings and is about $^{2}/_{5}$ inch (10 mm) long with a sawlike apparatus for depositing eggs.

Identifying the Injury. — Newly hatched larvae feed in groups on the old growth. They consume the soft outer tissue of needles, leaving the remainder to turn reddish brown. Twigs with damaged and discolored needles can be easily seen, and are called "flags". Older larvae feed singly or in pairs and consume the entire needle, leaving short stubs on the branch.

Biology. — There is only one generation per year. The overwintering eggs hatch during March and April. Larvae feed for 3 to 4 weeks before dropping to the ground and spinning cocoons in the litter and soil.

Pupation takes place in October or November, just prior to adult emergence. After the female mates, she lays a row of 2 to 10 eggs in the middle portion of each needle, laying between 90 to 120 eggs overall.

Control. — Natural enemies and a polyhedrosis virus are very effective at controlling outbreaks. Chemical control would be warranted only after several consecutive years of defoliation in the same timber stand.

Larva.

Photo: L.E. Thompson, Univ. of Arkansas

PINE COLASPIS,
Colaspis pini Barber

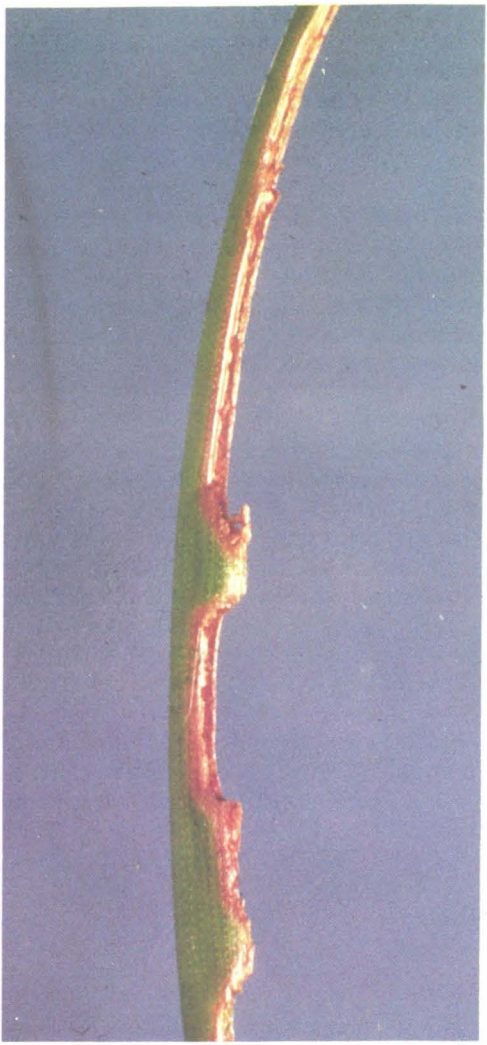
Importance. — Pine colaspis beetles are commonly found throughout the southeast, but are more prevalent in the Gulf states. They prefer slash pine but have been found on other southern pines, baldcypress, and ornamental spruce. Pine colaspis beetles are not serious forest pests. However, feeding damage caused by large beetle populations can cause a spectacular browning effect.

Identifying the Insect. — Adults are elongate-oval, convex, and rusty yellow or brown with green reflections. These moderate sized beetles are about ¼ inch (6 mm) long. Full grown larvae are sparsely covered with short hairs. Small clusters of longer hairs occur at the lower outer edges of each body segment.

Identifying the Injury. — Adult beetles chew the edges of needles, producing irregular, sawlike edges that turn brown. Later the entire needle may die, causing the whole tree to become brown as though scorched by fire. Occasionally, only the tips of the needles show signs of injury. Trees do not die, and little or no growth loss results. Attacks usually occur in early summer. By late summer the trees appear green and healthy again.

Biology. — There is only one generation per year. Eggs are laid on herbaceous undergrowth during the summer. Larvae emerge, feed on roots of grasses and other vegetation, and overwinter in this stage. The larvae pupate in the spring; adults emerge in early summer.

Control. — Under forest conditions, no control measures are recommended. On ornamentals and shade trees, insecticides can be used to prevent unsightly damage.



Feeding damage on needle.

PINE WEBWORM,
Tetralopha robustella Zeller

Importance. — The pine webworm occurs in southern Canada and throughout most of the eastern half of the United States and attacks pitch, Virginia, white, shortleaf, longleaf, loblolly, and slash pines. The pine webworm usually attacks one and two year seedlings, but will infest saplings and large trees. Rarely is defoliation severe enough to kill the seedlings, but it may have some growth impact.

Identifying the Insect. — The adult moth is dark to medium gray, with dark gray to black forewings on the basal third and outer half. Wingspread is approximately 1 inch (25 mm). The larvae are light gray with darker tan stripes along the body. They are approximately ¾ inch (18 mm) in length when fully grown. The pupae are reddish in color and approximately ½ inch (12 mm) long.

Identifying the Injury. — The most noticeable sign of attack, and usually the first, is a large mass of frass and excrement pellets entangled in a network of silken webbing. Close examination of this mass of material will usually reveal one or more larvae.

Biology. — Eggs are usually laid on seedlings, or occasionally on larger trees, between May and September. After the eggs hatch, the caterpillars live in silken webs surrounded by masses of frass and feed on the needles. After feeding is completed, the caterpillars drop to the ground and pupate in the soil. In the South, there are usually two generations per year.

Control. — In plantations, hand-picking is an effective method of control. When high value nursery stock becomes infested, chemical control may become necessary.

Frass and excrement pellets entangled in webbing.

Larva.

REDHEADED PINE SAWFLY, *Neodiprion lecontei* (Fitch)

Importance. — The redheaded pine sawfly is an important pest in young, natural pine stands and plantations. Heavy defoliation can lead to growth loss and tree mortality. The redheaded pine sawfly occurs in southeastern Canada and throughout the eastern and southern United States. Loblolly and longleaf pines are preferred hosts, although shortleaf, pitch, and slash pines are also attacked.

Identifying the Insect. — The mature larva is easily identified by its bright red head. The body is about 1 inch (25 mm) long and pale whitish yellow to bright yellow in color, with 4 to 6 rows of black spots on the body. The cylindrical cocoon is reddish brown and about ½ inch (12 mm) long. The adults resemble flies. They have four transparent wings and vary from 1/5 to 2/5 inch (5 to 10 mm) in length.

Identifying the Injury. — Larvae feed in colonies containing a few to over a hundred larvae. Larval feeding generally occurs on trees under 15 feet (5 m) in height. Young larvae feed on the outer portion of the needles. The unconsumed portions of needles have a strawlike appearance. Older larvae strip branches of all foliage and sometimes feed on tender bark when foliage is scarce.

Biology. — This sawfly overwinters in the larval stage within cocoons located in the soil or duff. Adults emerge in the spring. The female lays approximately 120 eggs in rows on the needles of a single twig. Each egg is deposited in a small pocket sawed into the edge of the needle. Eggs hatch in about 2 to 4 weeks, and larvae feed gregariously for about 4 weeks. Larvae then drop to the ground and spin their cocoons. In most of the South, there are two generations per year, but in Florida there are usually three.

Control. — Outbreaks occur periodically and tend to subside after 1 to 2 years of heavy defoliation. Natural factors and climatic conditions help control populations. A polyhedrosis virus is being used to control outbreaks of the redheaded pine sawfly. Chemical insecticides also may be used.

Larvae.

TEXAS LEAFCUTTING ANT, *Atta texana* (Buckley)

Importance. — The Texas leafcutting ant, or town ant, is a serious pest of pine regeneration in the upland areas of west central Louisiana and east Texas. It does not occur in other forested areas across the South.

Identifying the Insect. — Leafcutting ants are rust colored with large heads. They live in large colonies. The queen is ¾ inch (18 mm) long, and lives in an underground chamber. The worker ants are most numerous and range in size from 1/10 to ½ inches (3 to 12 mm) long. Ant nests consist of numerous crescent-shaped mounds on the surface and extensive underground passageways and chambers. The mounds may be restricted to a small area or extend over an acre or more. Foraging trails cleared of vegetation are often present around the central town area.

Identifying the Injury. — Leafcutting ants will attack hundreds of plant species. They damage all species of southern yellow pine by removing the needles, buds, and bark of seedlings during the winter and early spring when other green vegetation is unavailable. This is when large acreages of pine regeneration can be killed around leafcutting ant colonies. Once the seedlings have reached the height of 2 to 3 feet, they are rarely killed by leafcutting ants.

Biology. — The ants have a mating flight in May or June. After mating, the females establish nests beneath the soil and become the queens of the colonies. Worker ants carry the cut foliage and other vegetative material back to the nest, where it is used to culture the fungus that is their primary food.

Control. — There are few natural enemies. Control can be attained by fumigating the nest.

Adult worker.

Photo: Scott Cameron, Texas Forest Service

VIRGINIA PINE SAWFLY,
Neodiprion pratti pratti (Dyar)

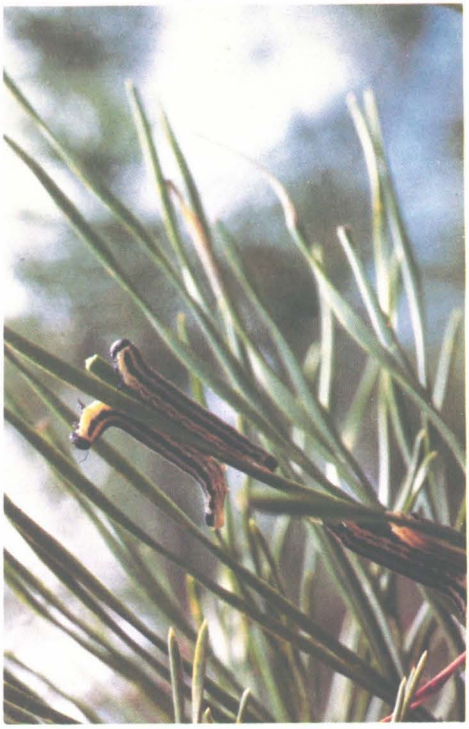
Importance.— Heavy defoliation by the Virginia pine sawfly for two or more years can weaken trees and make them more susceptible to other insects and diseases, particularly when associated with drought. In commercial shortleaf pine stands, the growth loss caused by two successive years of 50 percent defoliation can amount to one-third of the expected increment over a 4-year period. This sawfly is found from New Jersey to North Carolina. The insect prefers Virginia and shortleaf pines, but will occasionally feed on pitch and loblolly pines.

Identifying the Insect.— Larvae are pale green, with black head capsules, and about $^{1}/_{10}$ inch (3 mm) long when newly hatched. Full-grown larvae are spotted or marked with longitudinal black stripes and are from $^{6}/_{10}$ to $^{9}/_{10}$ inch (16 to 23 mm) long. The adults have four membranous wings.

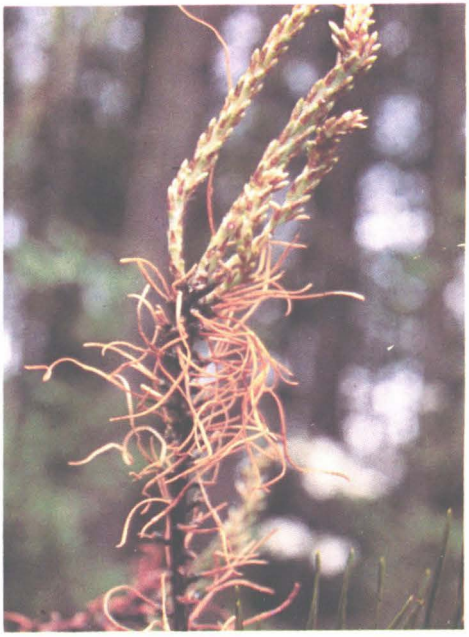
Identifying the Injury. — Young larvae feed gregariously on the previous year's foliage. They consume the outer portion of the needle, causing the remaining part to take on a strawlike appearance, which is characteristic of early sawfly feeding. Mature larvae consume the entire needle and may feed on the buds and tender bark.

Biology.— Adults emerge from cocoons in late October and early November. After mating, the female cuts a slit at the edge of the needle and inserts a small, white, oval egg. Several eggs are usually laid at evenly spaced intervals in each needle. Each female lays from 30 to 100 eggs. The eggs overwinter and hatch the following April. Around mid-May, the full-grown larvae drop to the ground and spin cocoons in the litter or surface soil. They pupate in late September. There is one generation per year.

Control.— Natural enemies, including a polyhedrosis virus, and adverse weather conditions seem primarily responsible for the drastic fluctuations in sawfly populations. Chemical insecticides can be used to control the sawfly.



Larvae.



Feeding damage on terminal.

AMBROSIA BEETLES, *Platypus* spp.

Importance.—Ambrosia beetles of the genus *Platypus* attack most species of pine and hardwood trees. They severely infest weakened and dying trees, green logs, and unseasoned lumber. Trees cut during the summer and left unmilled for more than 2 weeks are often severely damaged. This is especially true of gum, cypress, and oak trees. Ambrosia beetle attacks to green sawlogs and lumber may result in considerable degrade and strength reduction.

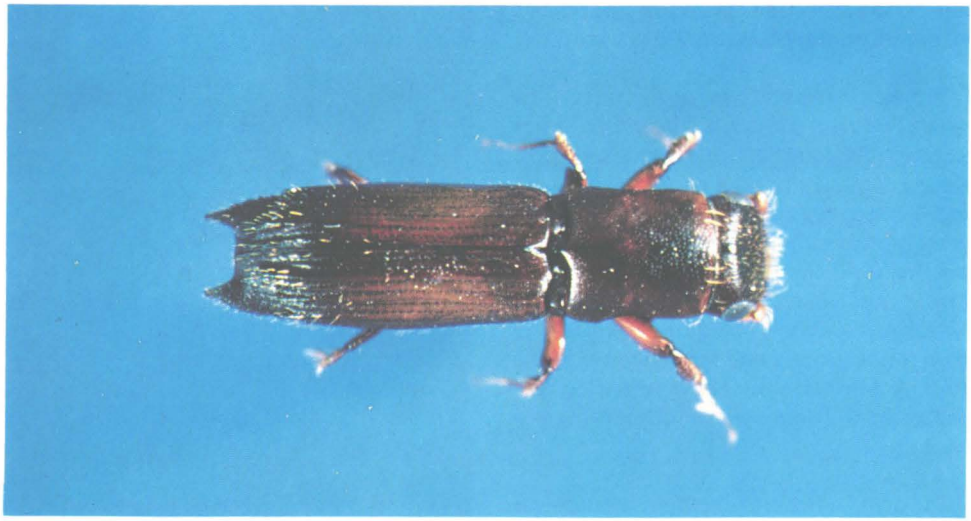
Identifying the Insect.—The adult beetles are elongate, dark reddish brown, about ¼ inch (6 mm) long, and usually have sharp spines at the rear.

Identifying the Injury.—In southern pines, large piles of a fine white granular dust accumulate below the entrance holes or at the base of standing trees. In lumber, the galleries are darkly stained.

Biology.—The adults and larvae do not feed on the wood but on a fungus the beetles carry into the tree and culture in the galleries. The adults bore into sapwood or heartwood of logs and lumber, making pin-sized holes which are stained by the fungus. The females lay eggs in small clusters in the tunnel, and the developing larvae excavate tiny cells extending from the tunnel parallel to the grain of wood. There may be several generations a year. Timber is not attacked unless the moisture content of wood is at least 48 percent. Seasoned lumber is never infested.

Control.—No chemical controls are recommended under forest conditions. Rapid utilization of cut timber and fast drying of lumber will prevent damage. Winter harvesting and water storage are also effective.

Boring dust at base of tree.



Adult

BLACK TURPENTINE BEETLE, *Dendroctonus terebrans* (Olivier)

Importance.—The black turpentine beetle is found from New Hampshire south to Florida and from West Virginia to east Texas. Attacks have been observed on all pines native to the South. This beetle is most serious in pine naval stores, pines stressed for lightwood production, and damaged pines in urban areas.

Identifying the Insect.—The adult insect is dark brown to black in color and ⅜ inch (10 mm) in length. The posterior end is rounded. Full grown larvae are white with a reddish brown head and about 1/3 inch (8 mm) long. Pupae are about ¼ inch (6 mm) in length and yellowish white.

Identifying the Injury.—Black turpentine beetles attack fresh stumps and the lower trunk of living pines. Initial attacks are generally within 2 feet (60 mm) of the ground. Attacks are identified by white to reddish-brown pitch tubes about the size of a half dollar. The pitch tubes are located in bark crevices on the lower tree bole, usually below a height of 10 feet (3 m). Infested pines are often attacked by other bark beetles.

Biology.—Adult beetles bore into the cambium and construct galleries which usually extend downward. Eggs are laid in clusters and hatch in 10 to 14 days. Larvae feed side by side, excavating a large continuous area. The life cycle takes from 2½ to 4 months, depending on the season. There are two to four generations a year.

Control.—Natural enemies and good tree vigor generally keep black turpentine beetle populations at low levels. Newly attacked trees can often be saved by spraying the base to the highest pitch tube on the trunk with an approved insecticide. Preventive sprays are also effective for high value trees. The prompt removal of infested trees also helps to control outbreaks. Forest management practices which promote tree vigor and minimize root and trunk damage help prevent infestations.

Large pitch tube.

Larvae feeding and excavation - note frass.

IPS ENGRAVER BEETLES,
Ips avulsus (Eichhoff), *grandicollis* (Eichhoff), and *calligraphus* (Germar)

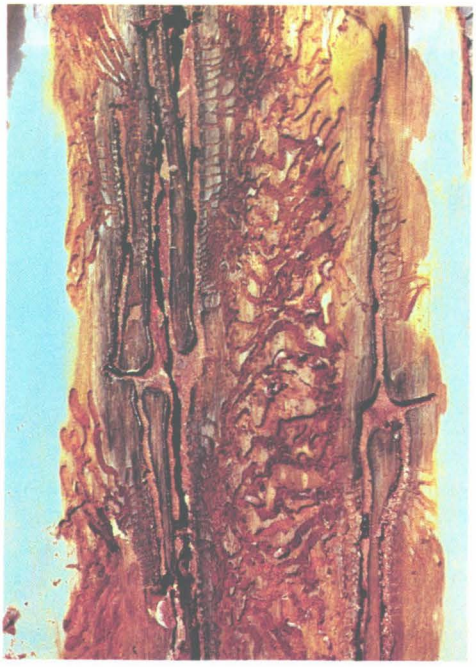
Importance.—*Ips* engraver beetles kill more pine timber in the South than any other forest insect, with the exception of the southern pine beetle. *Ips* beetles usually attack injured, dying, or recently felled trees and fresh logging debris. Infestations are particularly common in trees weakened by drought or lightning strikes.

Identifying the Insect.—Adult beetles are dark red-brown to almost black and 1/8 inch to 1/5 inch (3 to 5 mm) long. They are distinguished from other bark beetles by their scooped-out posterior with 4 to 6 spines on each side. Larvae have white bodies with orange-brown heads and are legless. Pupae are waxy-white and similar to adults in size.

Identifying the Injury.—The first signs of attack are reddish-brown boring dust in bark crevices or reddish-brown pitch tubes about the size of a dime on bark surfaces. If the bark is removed, there are Y- or H-shaped egg galleries with short larval galleries extending perpendicular to them. Egg galleries will usually be free of boring dust. The foliage of *Ips*-killed pines will eventually turn yellow, and then red about the time the beetles complete development under the bark. Often only the top portion of the crown is killed, leaving lower branches green. Blue-stain fungi, introduced when the beetles attack the tree, is visible in the sapwood and hasten the death of the trees.

Biology.—The female constructs an egg gallery and lays her eggs beneath the bark of attacked trees. The larvae make individual feeding galleries in the inner bark and pupate at the end of their galleries. New adults emerge after 21 to 40 days during the summer or after several months during the winter.

Control.—The best control is prompt removal and utilization of actively infested trees, making sure that the bark and slabs are destroyed. Insect parasites and predators, woodpeckers, and weather provide natural controls. Chemical control is seldom warranted under forest conditions, but may be used to protect pines in urban or high value areas. Preventive control practices include minimizing logging damage to residual stands and quick removal of felled trees.



Vertical egg galleries.

Ips adult.

SOUTHERN PINE BEETLE,
Dendroctonus frontalis Zimmermann

Importance.—The southern pine beetle is one of the most destructive pests of pines in the southern United States, Mexico, and Central America. This insect killed approximately 4.5 million board feet of pine timber from 1973 through 1977 in the southern United States. The beetle occurs from Pennsylvania to Texas and from New Mexico and Arizona to Honduras. It attacks and can kill all species of pines, but prefers loblolly, shortleaf, Virginia, pond, and pitch pines.

Identifying the Insect.—The adult is shortlegged, about ⅛-inch (3 mm) long, and dark reddish brown to black in color. The front of its head is notched, and the hind end of its body is rounded. The larva is crescent-shaped and whitish, with an amber head. When fully developed, larvae are approximately the same length as adults. The pupae are also the same size and white. The eggs are pearly-white and found in notches along either side of the adult egg galleries.

Identifying the Injury.—The adults bore directly through the outer bark into the living bark. At each point of attack, the tree usually exudes resin which forms a small pitch tube about the size of a small piece of popped popcorn. Adult beetles construct winding, S-shaped galleries, which cut across one another and girdle the tree. Blue-stain fungi in the sapwood, introduced by the beetles, hasten the death of the tree. The first indication of tree mortality is discoloration of the foliage. Needles become yellowish, change to a red color, and finally turn brown. Trees may be killed singly or in groups, ranging from a few trees to several hundred acres.

Biology.—Adults construct winding galleries in the inner bark, where eggs are deposited in individual niches on each side of the galleries. The eggs hatch into small larvae within 4 to 9 days. The larvae mine for a short distance before boring into the outer bark where they pupate. One life cycle can be completed in about 30 days under ideal conditions. There are from three to seven generations per year, depending on latitude, elevation, and climate.

Control.—Natural enemies, such as diseases, parasites, predators and weather, help maintain beetle populations at low levels and bring cyclic outbreaks under control. Integrated pest management may be achieved through any one or all of the following suppression techniques: rapid salvage and utilization of infested trees, piling and burning of infested materials, chemical control in high value resources, and cut-and-leave (May through October). To select the most appropriate strategy, the user is referred to the Integrated Pest Management Decision Key (IPM-DK). Good forest management is the most effective method of preventing losses from the southern pine beetle.

Egg galleries with larvae in larval mines.

Pitch tubes.

SOUTHERN PINE SAWYER, *Monochamus titillator* (Fabricius)

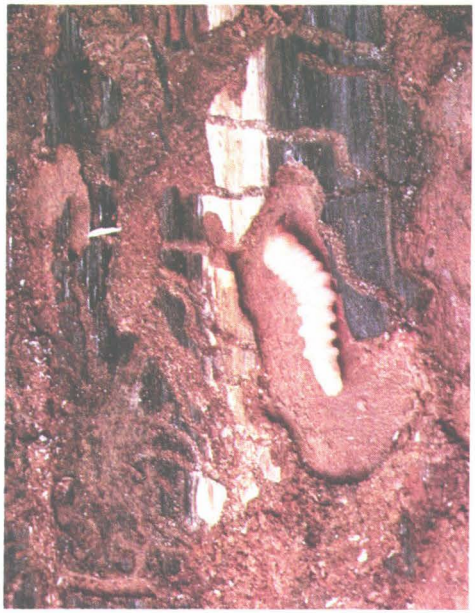
Importance. — This sawyer occurs throughout the eastern and southern United States and is destructive to pine logs held in storage or pines killed by natural or man-made catastrophes.

Identifying the Insect. — Adult beetles are mottled gray and brown from 1 to 1 ¼ inches (25 to 31 mm) in length and have antennae which are 2 to 3 inches (50 to 75 mm) long. Full-grown larvae are legless and whitish yellow in color and up to 2 2/5 inches (60 mm) long.

Identifying the Injury. — The first signs of attack are the funnel shaped pits or egg niches in the bark. Removal of bark from infested wood will reveal coarse, excelsior-like wood shavings, and sculptured wood. Elliptical shaped holes tightly packed with excelsior-like frass indicate that the larvae have bored into the sapwood to construct the pupal cell. Round, pencil-sized holes in the wood are exit holes.

Biology. — The adult beetle deposits one to several eggs in the cambium area through the egg niches. After hatching, the larvae feed on the surface of the cambium then bore into the sapwood and heartwood. After pupation is completed, the adult beetles chew through the wood, making the round exit holes. There are at least three generations per year in the southern United States.

Control. — Rapid utilization of dead and dying trees and green logs will reduce infestations and losses caused by this beetle. When large numbers of trees require storage, they may be sprayed with an insecticide or debarked. Logs stored in water may also prevent serious damage.



Larva in gallery with typical frass.

Adult.

DEODAR WEEVIL,
Pissodes nemorensis Germar

Importance.—Deodar weevil adults and larve can kill terminal and lateral branches, as well as girdle the stems of small trees. The weevil also vectors the pitch canker fungus, and its feeding wounds are infection courts for the pathogen. The weevil is found throughout the South and Mid Atlantic states. It attacks deodar and Atlas cedar, cedar of Lebanon, and various southern pines.

Identifying the Insect.—Adult weevils are rusty red to grayish brown, have long snouts, and are about ¼ inch (6 mm) long. The larvae are legless grubs, with a reddish-brown head. The life stages of the deodar weevil are similar in appearance to those of the white pine weevil. Where their geographic ranges overlap, identifiation of the pest is usually based on the host species and the portion of the tree infested.

Identifying the Injury.—During the fall, weevil larvae feed on the inner bark of leaders, lateral branches, and stems of small trees. Infestations usually remain unnoticed until the following January, when infested branches begin to turn brown. Small trees may be girdled and killed.

Biology.—Adults emerge during April and May, and feed briefly on the inner bark of nearby trees, sometimes girdling stems and twigs before dispersing for the summer. Adults feed occasionally during the summer. Feeding activity increases just prior to and during the fall reproduction period. Females lay from one to four eggs in feeding punctures. The newly hatched larvae bore into the inner bark, where they construct winding galleries which girdle the stem. Winter is spent in the larval stage. Pupation occurs in chip cocoons in the wood during March and April. There is one generation per year.

Control.—Keeping shade trees in a vigorous condition by proper watering and fertilization helps reduce their susceptibility to weevil attack. Insecticides can be used to protect high value trees.

Adult.

Pupation in chip cocoon.

NANTUCKET PINE TIP MOTH,
Rhyacionia frustrana (Comstock)

Importance.—This bud and shoot borer occurs throughout the East and South. Most species of pines are attacked, except longleaf and eastern white pine. Greatest economic losses result from retarding the height growth and deforming the main stems of trees in plantations. In pine seed orchards this pest kills female flowers and conelets.

Identifying the Insect.—Young larvae are cream colored with black heads. Mature larvae are light brown to orange and about $^{2}/_{5}$ inch (9 mm) long. The head, body, and appendages of the moth are covered with gray scales, while the forewings are covered with patches of brick-red and copper-colored scales.

Identifying the Injury.—Tip moths injure the growing shoots of young pines. Larvae bore into and feed on inner tissues of buds and shoots. Shoot injury occurs primarily during the first 5 years and decreases as crowns close. In seed orchards, boring frass, on the conelet surface and dead stalk, is the first indication of attack.

Biology.—This pest overwinters as a pupa, and adults emerge in late winter or early spring. Mating and egg laying occur shortly after emergence. Early larvae feed on needles and surfaces of new growth, while later larvae move to shoot tips and begin boring into buds or stem tissues. Pupation occurs within damaged shoots. There are 2 to 5 generations per year.

Control.—Control by insecticides is usually not recommended except for high value trees in seed orchards, nurseries, Christmas tree plantations, or for ornamentals.

Typical damage on shoot.

Adult moth.

Photo: R. Luck,
Univ. of California, Riverside, CA

PALES WEEVIL,
Hylobius pales (Herbst)
and
PITCH-EATING WEEVIL,
Pachylobius picivorus (Germar)

Importance.—In the South, reproduction weevils are the most serious insect threat to newly planted pines, particularly on recently cutover sites. The pitch-eating weevil is more common along the Gulf Coast. Feeding has been reported on most coniferous species, and all species of southern pines are susceptible to attack. Seedling mortality in plantations has been recorded as high as 90 percent, and 30 to 60 percent mortality is not uncommon.

Identifying the Insect.—Adult weevils are oblong, robust, black to reddish brown, and about ½ inch (12 mm) long. The wing covers have small, scattered patches of yellowish hairs. The pitch-eating weevil appears darker because the hairs on the wing covers are sparser and shorter.

Identifying the Injury.—Adult weevils feed on the tender bark of seedlings, twigs, or larger trees. Small, irregular feeding patches in the bark are characteristic of weevil damage. Heavy feeding may girdle the stem, causing wilting or death. Feeding below the root collar and on the roots is common.

Biology.—Adult weevils are attracted by the odor of fresh pine resin, and quickly invade recently logged areas. After mating, eggs are laid in lateral roots of fresh pine stumps. Eggs hatch in approximately 5 to 10 days. Larvae feed on the inner bark tissue of dead roots. Full-grown larvae construct a chip cocoon in the wood and pupate. The time spent in the pupal stage lasts from a few weeks to several months, depending on the temperature. Adult weevils are found year round, usually within flying distance of any pine cutting area. There may be two generations per year.

Control.—The insect can be controlled by delaying planting for one planting season in areas cut over after July, or by treating seedlings with a registered insecticide. Reducing the size of clear cuts prevents large populations of weevils from moving en-masse into new cutting areas.

Adult feeding.

WHITE PINE WEEVIL, *Pissodes strobi* (Peck)

Importance.—The white pine weevil is the most serious insect pest of eastern white pine. Weevil larve kill the last two-year's terminal growth and repeated attacks cause trees to become stunted and deformed to the point of being commercially unusable. Trees up to 3 feet tall may be killed. The weevil also attacks Norway spruce and jack pine and, to a lesser extent, pitch pine, red pine, Scots pine, and red spruce. It is found throughout the range of eastern white pine.

Identifying the Insect.—Adult white pine weevils are brown beetles about ¼ inch (6 mm) long. They have a long snout with antennae attached. White and tan spots of various sizes cover the body. The most conspicuous spots are towards the back of the wingcovers. Full-grown larvae are legless grubs with reddish-brown heads. They are ½ inch (12 mm) long.

Identifying the Injury.—In the spring, resin droplets ooze from feeding punctures on the terminal shoot, especially near the terminal bud. The most conspicuous sign of current weevil damage is a drooping of the terminal shoot caused by larval feeding. In the South, this "shepherd's crook" is usually noticeable in early June and by August it turns reddish brown. The terminal shoot dies, and one or more branches in the uppermost live whorl will assume dominance. This gives the tree a forked, crooked, or bushy form.

Biology.—Adults overwinter in the litter beneath host trees and emerge in the spring to feed on the leaders of their hosts. Females deposit eggs in small punctures in the bark of the leaders. The young larvae bore downward, side by side, in a ring. After feeding for 5 to 6 weeks, the larvae construct pupal chambers in the wood or pith of the terminal shoot, and cover themselves with shredded wood and bark. New adults leave the tree by late summer and do some feeding before overwintering. There is one generation per year.

Control.—Control of the white pine weevil is difficult. It is possible, however, to reduce the damage by making conditions in a young stand unfavorable for egg laying. Pine grown under a canopy of hardwoods is relatively free of weevil damage but requires intensive management. Under certain circumstances, insecticides can be used to protect the tops of trees.

Typical damage to terminal.

BALSAM WOOLLY APHID, *Adelges piceae* (Ratzeburg)

Importance.—The balsam woolly aphid was introduced from Europe around the turn of the century. It has become an important pest of true firs and is established throughout the Fraser fir type in the southern Appalachians. It is a serious pest of natural Fraser fir and also causes considerable damage to the Fraser fir Christmas tree industry.

Identifying the Insect.—Adult aphids are blackish purple, roughly spherical in shape, less than 1/32 inch (1mm) long, and almost invisible to the naked eye. The aphid produces a covering of white wax threads and appears as white, woolly dots about the size of pin heads on the surface of the tree's bole, limbs, and buds. Eggs are produced under the adults and are orange in color. The immature stage of the aphid, known as a "crawler," is also orange, with legs and black eyes. Eggs and crawlers can be identified with the aid of a hand lens.

Identifying the Injury.—During the aphid's feeding process, the host tree is stimulated to produce abnormal wood cells. This reduces the tree's ability to translocate food and water. Initial symptoms of aphid attack may include gouting of buds or twig nodes and some twig and branch dieback. This is very evident on seedlings, young understory trees, and Christmas tree plantings. Other damage may be stunted shoot and needle growth and loss of apical dominance in natural stands. A heavily infested tree may die within 2 to 7 years. As the tree dies, portions of the crown or the entire crown will turn red.

Biology.—The aphid has two generations per year, and occasionally three in the southern Appalachians. Eggs of the first generation hatch in late June and July, followed by a second generation in September and October. The "crawler" is the only mobile stage in the aphid's life cycle. When a crawler begins feeding, it transforms into a first instar nymph and becomes stationary. Reproduction is parthenogenic; each female lays up to 200 eggs. The aphid overwinters as a first instar nymph and continues its development in the spring when the host tree starts its annual growth cycle.

Control.—Chemical control is effective, but extremely costly. Thus it's usually limited to high value resources such as recreation areas, seed sources, and shade, ornamental, and Christmas tree plantings. Other control measures include removal and destruction of infested trees.

Aphids on bole.

Firs killed by the aphid.

DISEASES

ANTHRACNOSE,
caused by several fungi

Importance.—The greatest impact of anthracnose is in the urban environment. Reduction of property values, resulting from the decline or death of shade trees, is common. Various hosts are affected, including: sycamore, oak, ash, dogwood, and walnut.

Identifying the Fungi.—The fungi which cause anthracnose are different for each host. The fruiting bodies, which occur on twigs and leaves, are distinctive in color and shape. Samples of affected twig and leaf material should be sent to a specialist if this disease is suspected.

Identifying the Injury.—Injury usually includes irregular patches of dead leaf tissue (blotches), blackened bases of the leaf stem, cankering of the branch at the base of the leaf stem, and shoot dieback. Cankering is not commonly seen on walnut.

Biology.—Infection of oaks and sycamores begins with the leaves. The fungus grows through the veins, down the leaf stem, and into the branch. The fungus survives through the winter in branch canker tissue, and infection of emerging leaves occurs in subsequent years from spores produced on these cankers. The fungi also overwinter in diseased leaves in all hosts. Adverse impact of this disease is directly related to heavy rainfall, low temperature, and low host vigor.

Control.—No control is practical in the forest due to the cost. In high value trees, pruning, raking, and burning infected material, coupled with fertilization, improves appearance and may reduce subsequent infection.

Anthracnose on sycamore twigs.

Sycamore anthracnose.

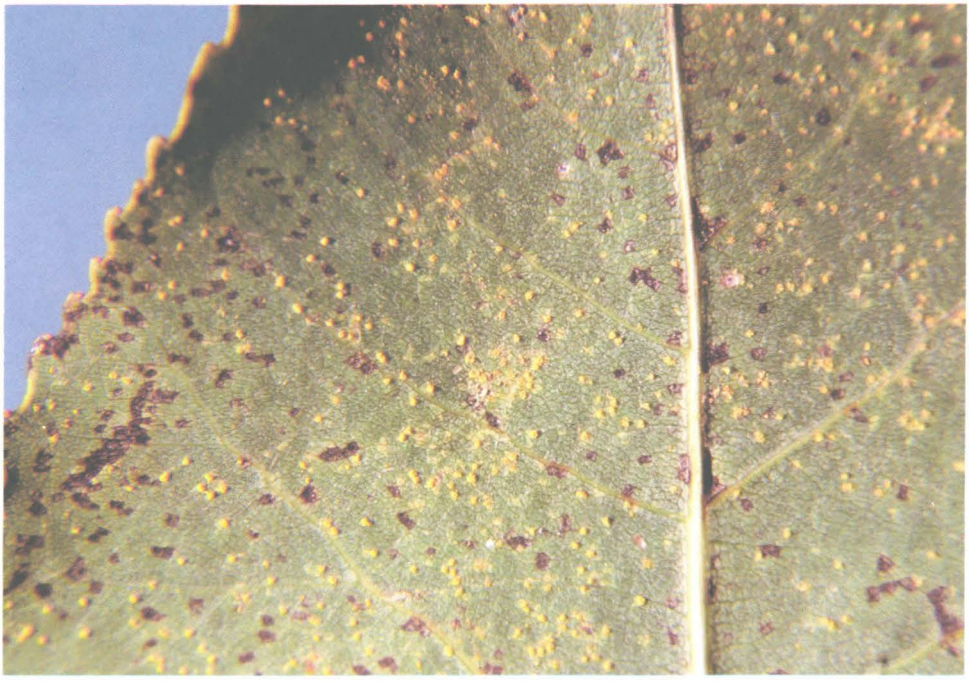
COTTONWOOD RUST,
caused by *Melampsora medusae*

Importance. — All sizes of cottonwood are affected, but cottonwood rust is particularly severe in plantations and nurseries. Heavy infection and subsequent defoliation may kill trees. The rust may also act as a predisposing agent to other diseases. Affected trees may be partially or completely defoliated.

Identifying the Fungus. — Yellow or orange pustules, containing spores, form on the under-surface of the leaves in midsummer. These are replaced by dark brown fungal growths in the fall.

Biology. — The orange pustules (uredia) are the summer reproductive state of the fungus. They are followed by dark brown pustules (telia) which develop in fall and winter. In the South, the alternate host (larch) is not present in the forest, and the fungal life cycle is reduced to the uredia-urediospore cycle only. Some families are immune to rust infection and disease-free trees or groups of trees often occur in the midst of other heavily infected trees.

Control. — Resistant varieties of cottonwood are used to minimize damage. Generally, no control is attempted in forest stands.



Rust infected cottonwood leaf.

BLACK KNOT,
caused by *Dibotryon morbosum*

Importance.—Black knot is an important disease of cherry, because it degrades this valuable veneer and lumber species. Except for southern Florida and southern Louisiana, this disease is found throughout the Southeast. Many species of cherry are affected, but black cherry is the only commercially important species. The disease is rarely fatal.

Identifying the Fungus.—Swellings on the branch of the host plant are covered with an irregular, rough, fruiting layer of fungal tissue. Spore bearing fruiting bodies form within this fruiting layer. The fruiting bodies and the spores are easily recognized by a specialist.

Identifying the Injury.—Black knot is a disease that causes irregular black swellings on black cherry stems, branches, and twigs. Often a white fungus is found growing over the swellings. Later, the swellings blacken and appear rough.

Biology.—Infection occurs during the spring, and swellings develop the following spring. These swellings are overgrown by a black irregular mass of fungal fruiting bodies.

Control.—Control is generally achieved by pruning out diseased tissue along with at least 12 inches (30 mm) of uninfected wood. In forest stands, trees with infections on their boles should be removed during improvement thinnings.

Black knot swellings on cherry.

HARDWOOD LEAF DISEASES OF MINOR IMPORTANCE

Disease Agent	Injury	Control
Powdery mildew, caused by *Microsphaera* spp., *Phyllactinia* spp. and others. These fungi overwinter on dead leaves. Spores are windblown to healthy leaves.	A white, powdery mold occurs on leaves and buds. Leaves may be distorted, stunted and fall prematurely.	2 3
Leaf blister, caused by *Taphrina* spp. This fungus overwinters on bud scales. When buds expand, infection of new leaves occurs. Spores produced on leaves are disseminated by wind.	Yellowish-green to purple blisters appear on leaves. Blistered leaves remain on the tree.	1 2 3
Leaf spots, caused by various fungi. Fungi overwinter in leaf tissue; spores are disseminated by wind and rain.	Small round to angular spots, variable in size and color appear on leaves. Defoliation may occur in extreme cases.	1 2 3
Nutrient deficiencies. These physiological conditions are soil related. Soil condition, such as pH, may make nutrients unavailable to plants, or the soil may be exhausted of some nutrients.	Leaf tissue turns yellow to brown; often this happens first along the veins. Some leaf fall may occur. Dieback may occur later if uncorrected.	4

Controls for Urban Trees

1. Rake and destroy fallen, infected leaves.
2. Maintain high vigor through cultural practices.
3. Control with chemical fungicide.
4. Control with appropriate fertilizer.

Pesticides

There are EPA registered chemicals for the control of these leaf diseases. Consult a specialist if the damage appears to be unusually severe and chemical control is needed.

Leaf blister on oak.

Leaf spots.

NECTRIA CANKER,
caused by *Nectria galligena* and *N. magnoliae*

Importance. — Nectria canker is the most common canker disease of hardwood trees. It seriously reduces the quantity and quality of forest products. This disease usually does not kill trees, but causes serious volume losses. It is common on yellow birch, black walnut, and sassafras. It also occurs on aspen, red oak, maple, beech, poplar, and birch.

Identifying the Fungus. — The fungus can be identified by the creamy-white fruiting structures that appear on cankers soon after infection. It can also be identified by the pinhead-sized, red, lemon-shaped perithecia near canker margins after 1 year.

Identifying the Injury. — Well-defined localized areas of bark, cambium, and underlying wood are killed by the fungus. Concentric, annual callus ridges develop around the expanding canker, and bark sloughs off the older parts of the canker. After several years, the canker resembles a target.

Biology. — The fungus survives through the winter in cankers, and produces spores during the spring. Windblown and water-splashed spores infect tree wounds and branch stubs.

Control. — Cankering may be minimized in high value areas by avoiding wounds and pruning out branch cankers. Sterilize pruning tools before moving to an uninfected tree and conduct pruning operations during dry periods when spores are less abundant.

Target-shaped nectria canker on walnut.

HYPOXYLON CANKER, caused by *Hypoxylon* spp.

Importance.—Fungi in the genus *Hypoxylon* generally cause a white rot of hardwood slash. However, some species are known to cause severe cankering of stressed hardwoods. Cankering caused by this fungus contributes to the premature death of trees stressed by drought, construction damage, or other problems. Rapidly rotting tissue leads to structural weakening, which causes serious hazard to people or property in high-use areas.

Identifying the Fungus.—The fungus is usually visible as a definite fruiting layer that has dislodged the bark. Fruiting layers vary in color. Hundreds of small, black fruiting bodies are imbedded in this layer.

Identifying the Injury.—The fungus invades the tree's cambium, and the fruiting layer exerts sufficient pressure to dislodge the bark. Careful observation is sometimes needed to see the fruiting layer, since it can resemble the bark of some trees, such as hackberry.

Biology.—Weakened trees are most often attacked by *Hypoxylon* spp. The fungal spores enter wounds, germinate, and grow into the cambium, severely cankering and often girdling the tree very quickly. Concurrently, white rot of the sapwood under the canker begins. Fruiting structures eventually cover the cankered area and rupture the bark. Spores are produced at a rapid rate and are wind borne to new hosts.

Control.—Disease prevention can be achieved in high value trees by keeping the tree vigorous and unwounded. Fertilize high value trees and water them during drought periods. Once infection has occurred, remove infected limbs or trees, because they rapidly become hazardous to people and property.

Hypoxylon canker on oak.

STRUMELLA CANKER,
caused by *Strumella coryneoidea*

Importance.—Strumella canker is less common in the southern Appalachians than in the Northeast. Its most common hosts are members of the white oak group; however, beech, basswood, blackgum, and shagbark hickory are occasionally affected.

Identifying the Fungus.—The fungus produces dark brown, cushion-like structures, about $^1/_{20}$ to $^1/_{10}$ inches (1 to 3 mm) in diameter, on dead bark and surrounding tissue. *Urnula craterium* has been described as the perfect or sexual stage of the fungus causing strumella canker. The urnula fruiting body is cup-shaped and grows on infected branches and stems that have fallen to the ground.

Identifying the Injury.—Strumella cankers are of two types; diffuse and the more common target shape. Diffuse cankers develop on smooth-barked saplings and rapidly girdle and kill the trees. Target-shaped cankers are more common and are formed by the alternation of cambium killed by the fungus around the canker perimeter and then the formation of a callus ridge by the host. Cankers can reach several feet in length.

Biology.—As with many canker diseases, the fungus usually enters the tree through a branch stub. The remnants of this stub can be seen at the canker center. Frequently, diseased trees bear multiple cankers.

Control.—There is no control for this disease under forest conditions. However, cankered trees should be removed during sanitation or commercial thinning operations. Severely diseased trees in recreation areas should be removed for safety.

Oak killed by strumella canker.

CHESTNUT BLIGHT,
caused by *Endothia parasitica*

Importance.—The chestnut blight fungus has virtually eliminated the American chestnut, as a commercial species, from eastern hardwood forests. Although roots from trees cut or killed many years ago continue to produce sprouts that survive to the sapling stage before being killed, there is no indication that a cure for this disease will be found. The fungus is widespread and continues to survive as a nonlethal parasite on chinkapin, Spanish chestnut, and post oak.

Identifying the Fungus.—The fungus forms yellowish or orange fruiting bodies (pycnidia) about the size of a pin head on the older portion of cankers. Spores may exude from the pycnidia as orange, curled horns during moist weather.

Identifying the Injury.—Stem cankers are either swollen or sunken, and the sunken type may be grown over with bark. The bark covering swollen cankers is usually loose at the ends of the canker. Trees die back above the canker and may sprout below it. Frass and webs from secondary insects are common under loose bark.

Biology.—Host infection occurs when fresh wounds in the bark become infected with spores that are disseminated by wind, birds, rain, and insects. Cankers kill the cambium and girdle the stem. Multiple cankers on infected trees are common.

Control.—No effective control has been developed for chestnut blight, even after decades of intensive research. Current research is targeted toward finding a blight-resistant species and the further development of the hypovirulent strains of the fungus. These strains tend to inactivate the pathogen and promote healing, but only when applied directly to developing cankers.

Cracking, and fruiting bodies, on chestnut.

Basal cracking caused by chestnut blight fungus.

OAK WILT,
caused by *Ceratocystis fagacearum*

Importance.—Oak wilt is the most destructive disease of oaks in the upper Mississippi Valley. It also occurs throughout most of the South and can kill oaks rapidly, causing heavy losses. Red oaks are affected more frequently and severely than white oaks.

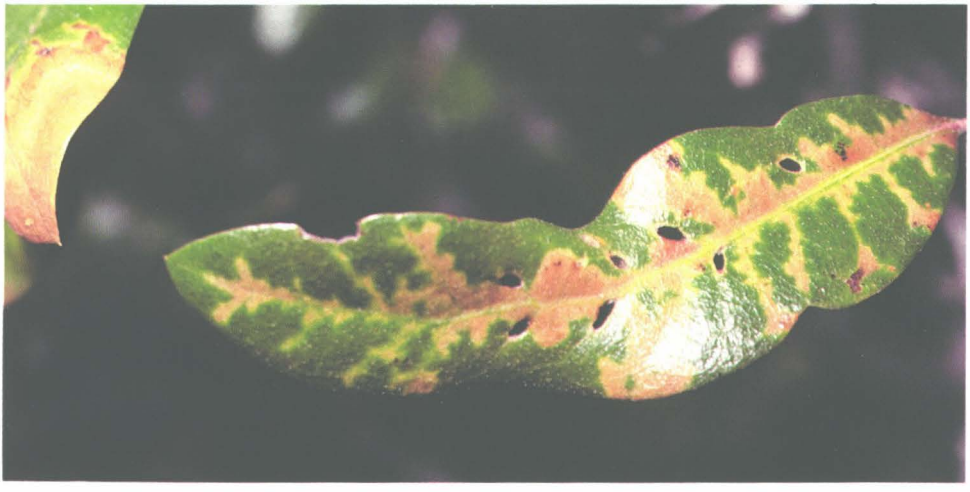
Identifying the Fungus.—The fungus can be identified in the field by the presence of fungal mats which form cushions under the bark of infected trees. However, these fungal mats are infrequently found in the South. Identification can also be made by observing laboratory isolates of the fungus.

Identifying the Injury.—Symptoms are bronzing or browning of green leaves from tips and margins downward toward the leaf base, premature defoliation, and eventually death of the tree. The red oaks develop symptoms over the entire crown shortly after infection, but white oaks develop symptoms slowly, a few limbs at a time.

Biology.—The wilt fungus is favored by moderate temperatures. It spreads from infected to noninfected trees through root grafts. In addition, insects can carry spores of the fungus over long distances.

Control.—In the forest, kill infected trees with silvicides to reduce inoculum and prevent root graft transmission of the disease. In urban areas, sanitation by removing infected trees and trenching to eliminate root grafts will minimize the losses.

Oak wilt infected tree.



Oak wilt symptoms on live oak.

DUTCH ELM DISEASE, caused by *Ceratocystis ulmi*

Importance.—Dutch elm disease primarily affects American and European species of elm, and is a major disease problem throughout most of the range of elm in the United States. The greatest economic loss results from death of high value urban trees.

Identifying the Fungus.—No fruiting bodies of this fungus are seen in the field. In the laboratory the fungus readily produces easily identified, spore bearing structures.

Identifying the Injury.—Symptoms of the disease include wilting, yellowing, and browning of the leaves, brown or purplish brown streaking of the wood under the bark, and crown dieback. Symptoms normally progress rapidly through the crown. Complete wilting often occurs within six weeks of infection.

Biology.—The fungus is transmitted to healthy trees in two ways: bark beetles transmit spores from diseased to healthy trees, or the fungus grows through root grafts between diseased and healthy trees. Generally, death of the infected tree is rapid. However, some asymptomatic trees have been found that had been infected for several growing seasons.

The specific manner in which the fungus kills trees is unknown. The vascular system of the infected tree is affected, reducing the conduction of water and nutrients.

Control.—The most available control is removing infected trees and promptly destroying the wood. If infected wood is to be used as firewood, it should first be debarked. Trenching to disrupt root grafts is recommended to protect healthy elm trees near diseased ones.

In urban situations, insecticide spraying of high value trees has been effective in keeping bark beetles from attacking susceptible trees. Space trees further apart to prevent root grafts or use mixed tree species in ornamental plantings.

Sterilize pruning equipment before use from one elm to the next to prevent spreading the fungus.

Yellow foliage caused by the Dutch elm disease fungus.

ELM PHLOEM NECROSIS,
caused by *Mycoplasma*

Importance.—This disease kills more elms than Dutch elm disease in many urban areas. It is prevalent in the eastern half of the nation. The disease is common on winged and American elms, but attacks all elms.

Identifying the Cause.—Mycoplasma, which are microscopic plants, cannot be field identified. Consult a specialist.

Identifying the Injury.—Symptoms appear initially on one branch or a small portion of the crown. Leaves wilt, become chlorotic, and their margins curl upwards. Defoliation follows, and the crown appears bushy. Defoliation and death can occur in a few weeks. Some of the brown, wilted leaves persist, separating these symptoms from Dutch elm disease.

This disease is identified by the butterscotch discoloration of the inner bark of the host tree. A wintergreen odor can sometimes be smelled after placing the affected bark in a vial or plastic bag.

Biology.—Leafhoppers that have previously fed on infected elms transmit the mycoplasma to healthy elms.

Control.—Removal of dying or dead trees will reduce the spread of this disease by reducing the source of the mycoplasma.

Butterscotch discoloration of inner bark.

MIMOSA WILT,
caused by *Fusarium oxysporium* var. *perniciosum*

Importance.—Mimosa wilt is the most devastating disease of mimosa. In many areas it has almost eliminated ornamental mimosas. The disease can be found from Maryland to Florida and west to Texas.

Identifying the Fungus.—Fruiting of the fungus is inconspicuous. Small pads of fungal tissue which bear spores are sometimes formed on dead twigs. Laboratory culturing and diagnosis are needed to identify the causal fungus.

Identifying the Injury.—Symptoms include chlorotic and wilting foliage. Discoloration of the outer ring of sapwood usually occurs, and trees may die within 6 weeks after becoming infected.

Biology.—The organism survives in soil and enters through the tree roots. While the specific mode of action of this fungus is not known, the effect is to disrupt the upward movement of nutrients and water.

Control.—Plant resistant varieties of mimosa.

Wilting, chlorotic foliage caused by the mimosa wilt fungus.

VERTICILLIUM WILT,
caused by *Verticillium albo-atrum*

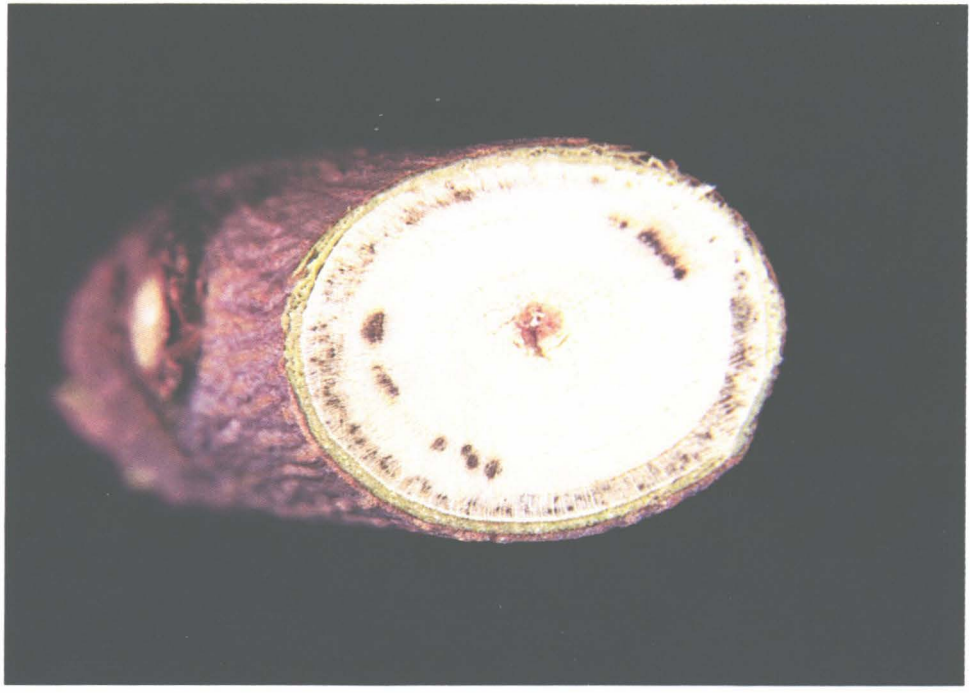
Importance.—*Verticillium albo-atrum* causes wilt disease in trees growing in ornamental settings, but diseased trees can occasionally be found in forest stands. Maples (sugar, silver, red, Norway) are favored hosts, but elms and other species are also infected.

Identifying the Fungus.—Laboratory culturing and microscopic observations are necessary for accurate identification.

Identifying the Injury.—Sympton expression can be quite variable. The foliage may yellow before wilting, and this may involve only a few twigs or branches. Occasionally, the entire crown may suddenly wilt. Dieback of twigs and branches may occur. Elongated stem and branch cankers may develop. Sometimes, green or green-brown discoloration occurs in the outer sapwood of the affected branches or stems. This discolored tissue readily yields the fungus on culturing.

Biology.—This is a soil fungus that requires wounds in order to infect the host. Infection normally occurs through roots and is spread throughout the tree by spores transported through the vascular system. Branch or tree death results from the disruption of the water-conducting tissue.

Control.—Control is most successful when initiated early. Fertilization with nonnitrate fertilizers, accompanied by adequate but not excessive irrigation, is recommended. If the tree dies, replanting with less susceptible species may prevent future disease.



Sapwood discoloration in maple twig.

CANKER ROTS,
caused by
Polyporus hispidus, Poria spiculosa, Irpex mollis, and others

Importance. — Many hardwood trees are susceptible, but oaks and hickories are commonly infected. Degrade and decay of hardwood lumber are the most important losses.

Identifying the Fungi. — Fungal fruiting bodies (conks) may be associated with the cankers and are variable. They can be toothed or pored; shelflike or flat, short-lived or persistent. *Poria spiculosa* produces sterile fungus material in the canker and only produces a fruiting body after tree death.

Identifying the Injury. — Cankers and associated localized decay vary in size, shape, and degree of callus formation. Dead branch stubs usually are located at the centers of the cankers.

Biology. — Airborne spores produced by the conks land on wounded areas and initiate new infections. An internal decay column can extend rapidly, sometimes by as much as 6 to 10 inches (15 to 25 cm) annually. It normally exceeds the external canker face in length. The fungus interrupts normal decay resistance processes and eventually kills the cambium. Callus tissue may be killed when the canker expands.

Control. — Removal of trees with cankered main stems provides more growing space to surrounding healthy trees and can also reduce conk and spore production. The pruning of declining branches may help prevent cankers in urban trees.

Polyporus hispidus conk growing above canker caused by the fungus.

Cross section of P. hispidus canker.

HEART ROTS,
caused by *Hericium erinaceus, Pleurotus sapidus, Polyporus fissilis,* and *Laetiporus sulphureus*

Importance. — Heart rot is the single most important disease of merchantable, hardwood timber in the South. Heart rot can affect all parts of the tree, but frequently occurs in the butt log, where its impact on the value of the tree is greatest.

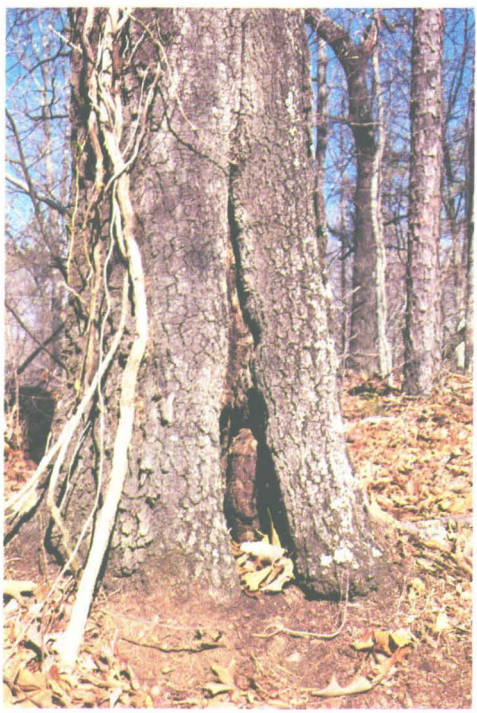
Identifying the Fungi. — Many fungi are responsible for heart rot in hardwoods; however, four species cause about half the damage. These are *H. erinaceus, P. sapidus, P. fissilis,* and *L. sulphureus.* These and other fungi can be identified by the conks they produce.

Identifying the Injury. — Damage resulting from most heart rots can be easily observed. Most begins at basal injuries, like those caused by fire and logging damage. In addition, poorly healed and decayed branch stubs and other stem defects are strong indications of heart rot.

Biology. — Heart rots begin through wounds, if the wounds are sufficiently deep or large. Healing is slow and permits a succession of chemical changes, and bacterial and fungal colonization. If the succession is complete, decay will be initiated and will continue for many years.

Control. — Once the decay process begins, there is no control. Consequently, prevention through the reduction of wounds from all agents is crucial to controlling heart rot. Affected trees that have any merchantable volume should be salvaged, while those that do not should be felled or girdled.

Heart rot developing on oak sprouts.



Basal heart rot on oak.

LUCIDUS ROOT AND BUTT ROT, caused by *Ganoderma lucidus*

Importance.—This disease is one of the most common root and butt rots of southern hardwoods. It has a wide host range including oaks, maples, hackberry, ash, sweetgum, locust, elm, mimosa, and willows, and is found throughout the South. Host trees normally decline for a variable period of time and then die.

Identifying the Fungus.—Fruiting bodies (conks) are produced at the butt or on exposed roots of affected trees. They have a stem, the tops are reddish to buff-colored, and the white undersurface is porous. Conks are tough, woody, and persistent.

Identifying the Injury.—Affected trees usually show a rapid decline, evidenced by shortened twig growth, off-color foliage, dwarfed and sparce foliage, and branch dieback. The rotten roots are white and spongy, with black flecks or dark lines.

Biology.—This fungus invades trees stressed or wounded by a variety of agents, including fire, soil compaction, construction injury, vehicular damage, herbicide injury, and lawnmowers. Airborne spores contact the wounds and invade susceptible tissue, spreading up into the butt of the tree or down into the root system, or both. Colonization of healthy trees may also occur through root grafts or contacts with diseased roots.

Control.—Preventing basal wounds is the best method of avoiding damage by root and butt rots. Irrigation and fertilization can help promote rapid wound healing and minimizes exposure of susceptible tissue to decay organisms. Susceptible tree species, like mimosa and oak, should not be planted where serious damage has occurred in the past.

Fruiting body of lucidus root and butt rot.

SHOESTRING ROOT ROT, caused by *Armillariellia mellea*

Importance.—This root rot fungus causes major losses throughout the United States. Windthrow of infected trees in urban and high-use areas creates safety hazards, contributing to the economic importance of this disease. Additional losses occur from reduced vigor in both conifer and hardwood species.

Identifying the Fungus.—In the fall, clumps of yellow mushrooms grow on the ground near the tree and occasionally on the bole several feet above the ground. *A. mellea* produces thin, black rhizomorphs that grow on the root surface. The rhizomorphs resemble black shoelaces.

Identifying the Injury.—Infected trees may have low vigor. Roots may show various degrees of decay, which generally becomes evident only on windthrown trees.

Biology.—The fungus can live in dead roots and stumps for many years. The fungus spreads through the soil via roots. Healthy roots that come in contact with infected ones can become infected. Mushrooms produce an abundance of spores, but they probably are not important in infecting living trees. The fungus is most pathogenic on slow-growing trees.

Control.—There is no practical control of the disease in forest stands. Spread can be reduced in urban environments by removing the infected trees, stumps, and large roots, and by sterilizing the soil before replanting. Any cultural practices that reduce stress and increase tree vigor will also reduce the potential for infection.

Decay caused by shoestring root rot fungus.

Shoestring root rot mushrooms.

NEEDLE CASTS,
caused by *Hypoderma* sp. and *Lophodermium* sp.

Importance.—Needle cast fungi are common diseases of conifers throughout the South. Infected trees in forest stands normally recover. However, losses to non-forest conifers, such as Christmas trees and nursery seedlings, can be substantial. Eastern white, loblolly, slash, shortleaf, Virginia, and Scotch pines, as well as spruce and firs, are susceptible.

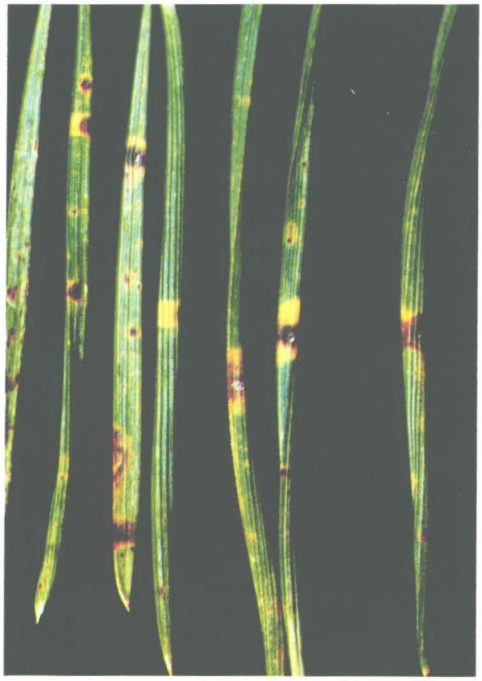
Identifying the Fungus.—There are over 25 needle cast fungi known in the South. They can be identified only after examining the spores microscopically.

Identifying the Injury.—Depending on the identity of the infecting fungus, needles begin to turn yellow-brown by winter or early spring. Later, the browning progresses, and fungal fruiting bodies are produced. These small, black, fruiting bodies may be bordered by brown or yellow margins, or both. In the more advanced stages, the tree has a scorched appearance.

Biology.—Generally, new needles are infected in the spring or summer. The fungi colonize the needle tissue, turning it yellow and later brown. Fruiting bodies are formed in these brown areas, which produce spores that are spread during wet weather to reinfect new needles on other trees.

Control.—No controls are practical in forest stands. Fungicide sprays may be applied in Christmas tree plantings and nurseries.

Needle cast on slash and loblolly pine.



Needle spots caused by a needle cast fungus.

BROWN SPOT NEEDLE BLIGHT, caused by *Scirrhia acicola*

Importance. — Longleaf pine is the only species in the South that is damaged by this disease. Seedlings are often heavily infected while in the grass stage and often die after repeated defoliations.

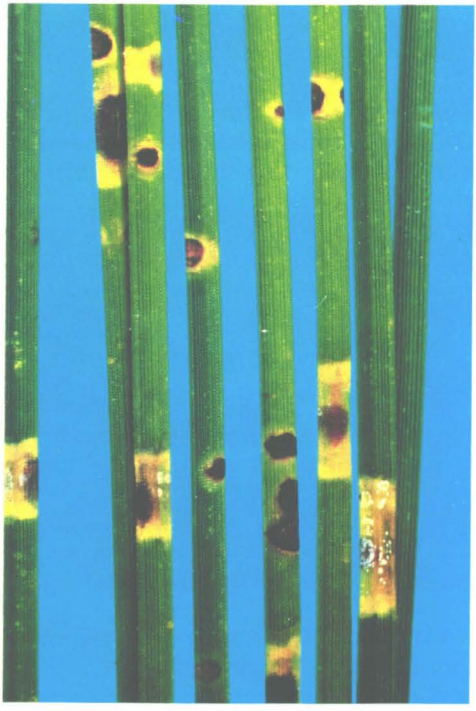
Identifying the Fungus. — Boat-shaped spores are produced in the yellow bands on the needles. Positive identification can be made by examining the spores under a microscope.

Identifying the Injury. — Infected needles develop grey-green spots, which later turn brown. Eventually, a yellow band develops on the needle. The affected area then increases in size, resulting in death of the needle.

Biology. — Spores are released from the fruiting bodies (acervuli) on the needles throughout the year. The spores are splashed short distances by rain drops. During the winter and early spring, perithecia are produced on dead needles. Spores from these perithecia are responsible for longer distance spread of the fungus.

Control. — Plant resistant or high-quality seedlings on intensively prepared sites. When seed trees are used, burn in the fall to destroy diseased needles. Where seedlings are established, burn during the dormant season. Remove seed trees when seedlings are 1 or 2 years old. Fungicide sprays are effective in controlling this disease in nurseries.

Brown spot needle blight on longleaf seedling.



Spots and discoloration caused by the fungus.

PINE NEEDLE RUST,
caused by *Coleosporium* sp.

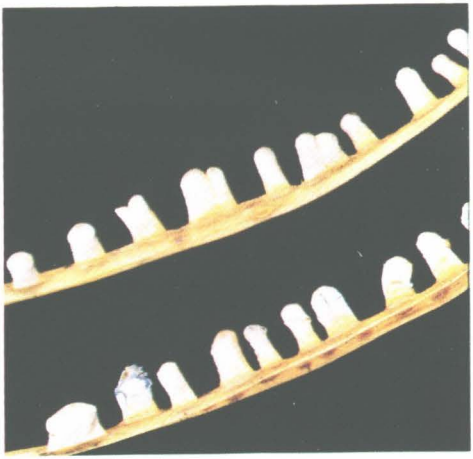
Importance.—Needle rust is most prevalent on young trees. The disease usually does not seriously damage trees, and is of most concern in Christmas tree plantings and nurseries. Most two- and three-needle pines throughout the South are susceptible. Goldenrod, asters, and other plants serve as the alternate hosts.

Identifying the Fungus.—The fungus has four stages. The aecial stage on the pine needles looks like small, white-orange "sacks." Aeciospores infect the alternate host, which results in orange, powdery spores on the leaves. Later orange, cushion-like objects, called telia, are produced on the underside of the leaf. The last stage (pycnial) looks like frosty, orange droplets on the pine needles.

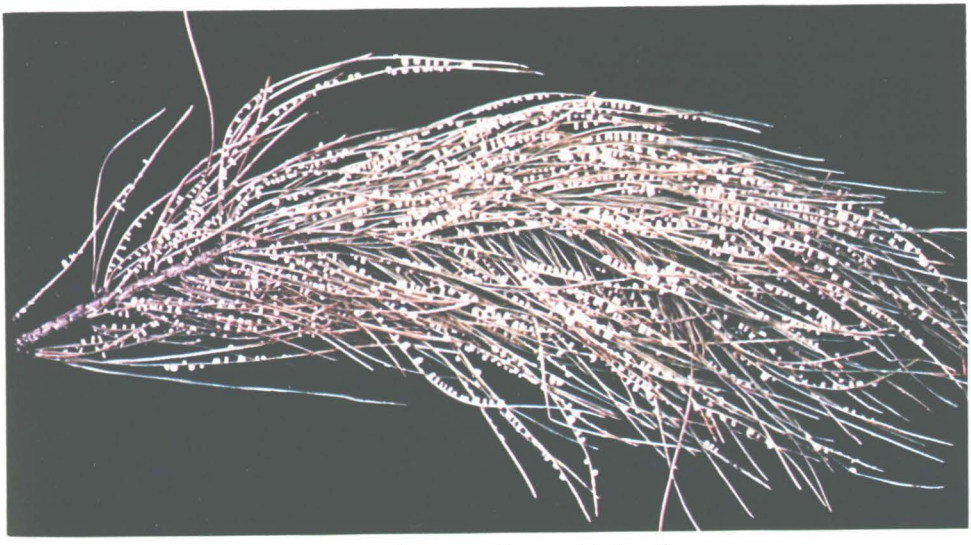
Identifying the Injury.—Infected pines often have white-orange blisters on the needles. Although these are actually fruiting structures of the fungus, they are an obvious feature of infection.

Biology.—Pycniospores form on pine needles in the spring; then orange, aecial blisters form. The spores from the aecial blisters infect the alternate hosts, which produces urediospores on the leaf. These spores reinfect the alternate host, but not the pine. Later, telia form on the leaves. These produce orange-yellow spores, which infect the pine.

Control.—No control is needed in forest stands. The alternate host can be reduced through mowing or the use of herbicides. This would only be justified around high-value areas, such as nurseries.



Fruiting bodies of pine needle rust.



Heavy pine needle rust infection.

CEDAR APPLE RUST,
caused by *Gymnosporangium juniperi-virginianae*

Importance. — The golfball-size galls that form on eastern redcedar (alternate host) are unsightly, but cause little harm to the tree. The primary hosts—apples—experience foliage loss, growth loss, reduced quantity and quality of fruit, and, in some cases, death.

Identifying the Fungus. — The fungus forms galls on the branches of eastern redcedar. In the spring, these galls produce long, orange tendrils or "horns." Leaf spots form on the apple host in the spring. These spots produce yellow spores on the lower surface of the leaf.

Identifying the Injury. — Brown, round galls form on the branches of redcedar, but they cause no injury. On apple leaves, yellow spots occur that later turn brown and result in cupping and curling of the leaf.

Biology. — The redcedar needles are infected in the summer by aeciospores from the apple host. The next spring, brown galls begin to appear on the needle. Later, larger brown galls, with small round depressions, form on the twigs. The next spring, orange, jellylike horns (telia) protrude from these galls. Spores, produced in these horns, infect the apple host, which results in leaf spots and the production of aeciospores.

Control. — Picking and disposing of the galls can improve the appearance of the redcedar. The stage on apple is generally controlled with fungicides. Reducing the number of eastern redcedars may reduce the occurrence of the disease on apple.

Fruiting on apple leaf.

Tendrils of cedar apple rust gall.

PHOMOPSIS BLIGHT,
caused by *Phomopsis juniperovora*

Importance.—Phomopsis blight is primarily a problem in nurseries, where entire crops can be lost. Although older trees are affected, the normal result of infection is only appearance. Eastern redcedar, Rocky Mountain cedar, arborvitae, cypress, and Atlantic white-cedar are hosts.

Identifying the Fungus.—The fungus forms small, black fruiting bodies on the needles and stems. These bodies contain small, oval spores.

Identifying the Injury.—Tips of branches are killed and turn brown. Formation of small, black fruiting bodies at the point between living and dead tissue is common.

Biology.—Young needles are infected by airborne and water-splashed spores. The fungus grows into the stem and causes death of the shoot. Fruiting bodies are then formed, which produce spores that infect other plants.

Control.—No economical control is available for forest trees. For nursery seedlings, fungicides are the primary means of control. Removing infected nursery stock, avoiding the movement of infected seedlings, moving the location of the beds, reducing the number of seedlings per square foot, and not using cedar mulch around the beds should also help.

Phomopsis blight on eastern red cedar.

Phomopsis blight.

FUSIFORM RUST,
caused by
Cronartium quercuum f. sp. *fusiforme*

Importance.—Fusiform rust infections that occur on the main stem within the first 5 years of a tree's life normally cause tree death. Infections that occur later in the life cycle of the tree weaken the stem, resulting in wind breakage at the canker or quality loss at rotation. Losses in individual nurseries can exceed 80 percent. Loblolly and slash pine are the most susceptible species. Longleaf is fairly resistant, while shortleaf pine is highly resistant. Oak is the alternate host.

Identifying the Fungus.—The fungus produces orange spores on the surface of fusiform-shaped pine galls in the spring. Orange spores are produced on the lower surface of the oak leaves. Later, hairlike structures are also produced on the leaf.

Identifying the Injury.—Spindle-shaped swellings or galls develop on the branches or main stem. Main stem infections on older trees are somewhat depressed on one side. Trees commonly break at the canker. In the spring, the galls turn orange. Infection on the oak host produces orange leaf spots and hairlike telia, which can cause cupping and curling of the leaf.

Biology.—Orange-yellow blisters form on the pine gall: the blisters produce aeciospores. In late spring, uredia are formed on the underside of young oak leaves. During late spring or early summer, brown, hairlike structures (telia) form on the oak leaves. Spores produced on the telia infect the pine.

Control.—The control strategies for fusiform rust are complex for forest stands and nurseries, and are too numerous to discuss here. The user is referred to the Integrated Pest Management Decision Key (IPM-DK) for more information. Discuss this with a State or Federal forest pest management specialist.

Fusiform rust fruiting on loblolly pine.

Fusiform rust damage to main stem.

COMANDRA BLISTER RUST, caused by *Cronartium comandrae*

Importance.—Comandra blister rust occurs in northern Arkansas, eastern Tennessee, and northern Alabama. Losses are low, but can exceed 40 percent in individual stands. The primary hosts are loblolly, shortleaf, pond, and Virginia pines. False toadflax (comandra), the alternate host, suffers minimal damage.

Identifying the Fungus.—The fungus produces orange spores on the surface of the pine galls in the spring. A different orange spore type is produced on the lower surface of the toadflax leaf. Later, hairlike structures are formed on the leaf.

Identifying the Injury.—Spindle-shaped galls form on the main stem or branches of the pine host. Portions of the tree beyond the galls normally die. In the spring, the galls turn orange. In the summer, orange leaf spots develop on the toadflax. The leaves later cup, curl, and turn brown.

Biology.—The fungus infects pine through the young needles and grows into the stem, where a gall is formed. Orange spores (aeciospores) are produced on the gall in the spring and infect the leaves or stems of comandra. Uredia are produced on the lower surface of the leaf. Urediospores, from the uredia, are windblown and infect toadflax plants. Later, hairlike structures (telia) are produced on the toadflax leaves and stems. The telia produce basidiospores, which infect the pine.

Control.—Forest management practices which reduce the alternate host—toadflax—may reduce the occurrence of pine galls.

Comandra blister rust fruiting on pine.

EASTERN GALL RUST,
caused by
Cronartium quercuum f.sp. *quercuum*

Importance.—This disease normally causes little or no damage in forest stands. It can, however, cause serious damage in nurseries where seedlings become infected and die. Losses also occur when infected, outplanted stock dies. The alternate host—oak—is not seriously damaged. A variety of pines are primary hosts, but Virginia, sand, and shortleaf pines are the most susceptible.

Identifying the Fungus.—The fungus produces orange spores on the surface of the round pine galls. Orange spores are produced on the lower surface of the oak leaves. Later, hairlike structures are produced on the oak leaves.

Identifying the Injury.—Round galls form on the main stem or branches. Portions of the tree beyond the galls normally die. In the spring, the galls on pines turn orange. In the summer, orange leaf spots develop on the oak host.

Biology.—Infection in the pines occurs through young needles. The fungus grows into the stem, where a gall is formed. Orange spores (aeciospores) are produced on the gall in the spring and infect oak leaves. Uredia are produced on the lower surface of the oak leaf. Urediospores, from the uredia, are windblown and infect the same or other oak plants. Later, hairlike structures (telia) are produced on the oak leaves. The telia produce basidiospores, which infect the pines.

Control.—Fungicides are used to control the disease in forest tree nurseries. The best control in forest stands is the removal of infected trees during thinning operations. Practices that reduce the oak population may reduce the occurrence of the disease on pine.

Eastern gall rust fruiting on pine.

SOUTHERN CONE RUST,
caused by *Cronartium strobilinum*

Importance. — This fungus seriously affects slash and longleaf pine cone crops in Georgia and along the Gulf Coast from Florida to Texas. Damage to oak, the alternate host, is minimal.

Identifying the Fungus. — The fungus requires two hosts. Orange spores are produced in blisters in the first-year conelets. These blisters burst, causing the cones to appear yellow-orange. Orange leaf spots are produced on the oak. Later, hairlike structures are produced on the oak leaf.

Identifying the Injury. — Infected first year conelets enlarge and swell 3 to 4 times their normal size. The swollen conelet scales are reddish in color. Later, the conelet appears orange in color. Infection on the oak host produces orange leaf spots and hairlike telia, which can cause cupping and curling of the leaf.

Biology. — Teliospores, which are produced on the oak host, infect the mature female pine flowers about the time of pollination. By May, the conelets are 3 to 4 times their normal size. Spores (aeciospores) are produced in blisters in the conelets. These spores are windblown to the oak host, where uredia are produced. The uredia produce spores (urediospores) which reinfect the oak host. Later, hairlike structures (telia) are produced on the leaves. These telia produce basidiospores, which then infect pine.

Control. — Applications of fungicides in seed orchards have been successful in fighting the disease.

Enlarged cone infected with southern cone rust.

PITCH CANKER,
caused by *Fusarium moniliforme* var. *subglutinans*

Importance. — Pitch canker can damage many pine species, including all of the commercially important southern pines. In forest stands, only plantations of slash, and occasionally loblolly pine, are seriously affected. While mortality can result from abundant cankering, losses from growth suppression are more common.

Identifying the Fungus. — Pinkish fruiting bodies (sporodochia) containing fungus spores are produced on cankered shoots in the needle scars and on the outer surface of bark. Microscopic features of the spore-bearing structures aid in identification.

Identifying the Injury. — Infected trees exhibit shoot dieback of the current year's growth, and abundant resin flow from the affected area. The wood beneath cankers is resin-soaked. The main terminal and upper laterals are most often affected.

Biology. — Fungus spores are airborne and spread in the summer during windy, wet periods. The spores infect wounds. The deodar weevil, which breeds in dying trees and feeds on the phloem of young branches, can transmit the disease. Spores are abundant in the litter beneath diseased stands, and fruiting bodies persist for months on diseased shoots.

Control. — No specific control procedures are available for pitch canker. Forest practices which maintain stand vigor—for example, thinning—may minimize disease hazard. Salvage harvesting of heavily diseased stands is recommended. Genetic resistance to the disease exists and should be included in future pest management strategies.

Shoot dieback caused by pitch canker fungus.

Resin soaked branch.

RED HEART,
caused by *Fomes pini*

Importance.—Red heart is of greatest significance in mature and overmature pines of all species. Infected trees suffer a loss of merchantable volume, in addition to being structurally unsound. The trees are valued, however, as woodpecker nesting sites.

Identifying the Fungus.—The fungus produces perennial conks, which are frequently hoof-shaped. Those that are not, lie flat against the stem, projecting a light brown surface outward. Hoof-shaped conks have a dull gray to dark brown upper surface, with concentric furrows parallel to the margin. The underside is light brown to brownish-gold, and velvety in texture.

Identifying the Injury.—Infected heartwood is often light red to reddish-brown. The advanced stages of heart rot appear as elongated white pockets or flecks parallel to the grain and separated by apparently firm wood. Affected trees exhibit swollen knots.

Biology.—Infection normally occurs through dead branch stubs. Infected trees can survive indefinitely, but can be structurally unsound. This is of particular importance in recreation areas, where large old-growth pines are common.

Control.—Control is limited to harvesting mature and overmature pines where woodpecker habitat is not a consideration. In areas of intense public use, trees of high aesthetic value can be somewhat protected by correctly pruning dead and dying branches on the main stem to minimize infection.

Red heart conk.

Advanced heart rot caused by red heart fungus.

ANNOSUS ROOT AND BUTT ROT, caused by *Heterobasidion annosum*

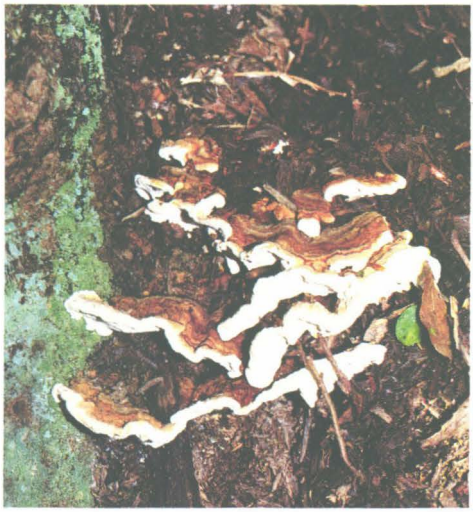
Importance.—Annosus root and butt rot is a commercially important disease of conifers. All southern pines are susceptible, but loblolly and slash pine are most severely affected.

Identifying the Fungus.—Conks are often present in the litter at the base of dead or dying trees or tree stumps, or under root masses of windthrown trees. Conks, when fresh, are tan to brownish on the upper surface and white with tiny pores on the lower surface. They are rubbery and tough to tear. In the southern United States, conks are most common from December through March.

Identifying the Injury.—Damage from annosus root and butt rot may be scattered throughout a stand or in pockets of dead and dying pine trees called "infection centers." Mortality is sometimes preceeded by thinning and yellowing of the crown; however, some trees simply turn red and die. Trees in various stages of dying or death may suffer windthrow. Infected roots exhibit resin or pitch-soaking, and stringy root decay.

Biology.—Annosus root and butt rot probably enters the stand when fungal spores land on fresh cut stump surfaces. The fungus grows through the remaining root system into nearby live trees via root grafts or contacts. Mortality usually begins 2 to 3 years after thinning and often ceases 5 to 7 years later. Damage increases with the sand content of the soil. Twelve inches (30 mm) or more of sand or sandy loam above a clay subsoil in a soil with good internal drainage is considered a high hazard site for tree mortality.

Control.—Prevention and control strategies for annosus root rot include stump treatment, timing of thinnings, prescribed burns, and the manipulation of planting density. To select the most appropriate strategy, the user is referred to the Integrated Pest Management Decision Key (IPM-DK). Discuss this with a State or Federal pest management specialist.



Annosus root and butt rot conks.

Resin soaked root.

Annosus root and butt rot infection center.

BROWN CUBICAL ROT,
caused by *Polyporus schweinitzii*

Importance.—This disease can affect all southern pines and is most prevalent in trees that have suffered basal wounds from fire, logging, soil compaction, or root injury. Diseased trees are subject to windthrow and breakage.

Identifying the Fungus.—The fungus produces annual conks which develop in late summer and fall, particularly during moist weather. When conks are produced on the base of trees, they are bracket-shaped, while those arising from infected roots are supported by a stalk and are circular with sunken centers. The upper surface is reddish-brown with a light yellow margin and has a velvety texture. The underside is dark olive or green, with large irregular pores.

Identifying the Injury.—The fungus develops primarily in the roots and butt and seldom extends more than 15 or 20 feet up into the stem. The initial stage of decay appears as a light yellow stain. In the advanced stage, the heartwood becomes brittle and breaks into large yellow-brown to reddish-brown cubes.

Biology.—Overmature, suppressed and weakened, or off-site trees are commonly attacked. Spores of the fungus enter living hosts through damaged roots, fire scars, and other wounds near the tree base. The fungus may also spread from infected to healthy trees through root contacts and grafts.

Control.—In forest stands, no method of controlling the disease is known. Losses may be reduced by minimizing stand entries and basal fire injuries. To avoid human injury or property damage, trees with advanced root and butt rot should be removed from recreation sites, parking lots, trails, and buildings.

Brown cubical rot conk.

Brown cubical rot.

RED ROOT AND BUTT ROT, caused by *Inonotus circinatus*

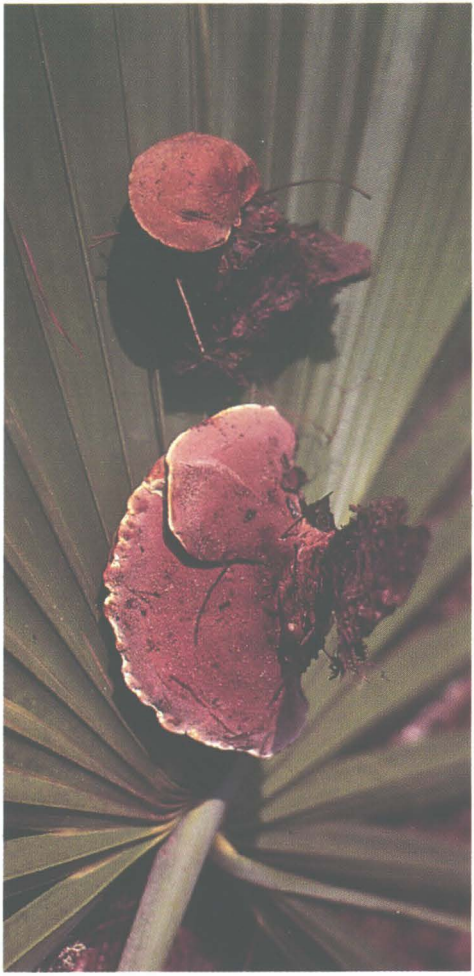
Importance.—*Inonotus circinatus* causes a root and butt rot of slash, sand, and shortleaf pines in the South. It is the fungus most often associated with diseased sand pines over 20 years old.

Identifying the Fungus.—The fungus produces fruiting bodies in the fall and winter on the bases of affected trees and from infected subsurface roots. Fruiting bodies are firm-textured and yellowish-brown, and can be bracket-shaped or have a well-defined stem. The lower surface of the fruiting body is composed of many pores.

Identifying the Injury.—Infected trees appear thin-crowned, with dwarfed, yellow needles. As the disease progresses, windthrow becomes common. Infected roots show a dark, reddish-brown stain. Resin often impregnates stained wood and exudes through the bark at the base of the tree. Roots with advanced decay have small, elliptical pockets filled with white mycelium.

Biology.—Red root and butt rot is a slow-acting disease, primarily of older pine stands. Trees may be infected by airborne spores that are deposited on basal wounds. Fusiform rust galls on slash pine seem particularly susceptible to infection. Once established in a tree's root system, the fungus can spread to healthy trees via root contacts. Diseased pieces of roots can persist in the soil for a number of years.

Control.—Direct controls for this disease are not available. Management techniques to minimize its impact are: sanitizing or completely salvaging affected portions of stands, including trees with basal rust galls; avoiding wounding trees during stand entries; lowering rotation age; and harvesting overmature stands.



Red root and butt rot conks.

LITTLELEAF DISEASE,
caused by a complex of agents

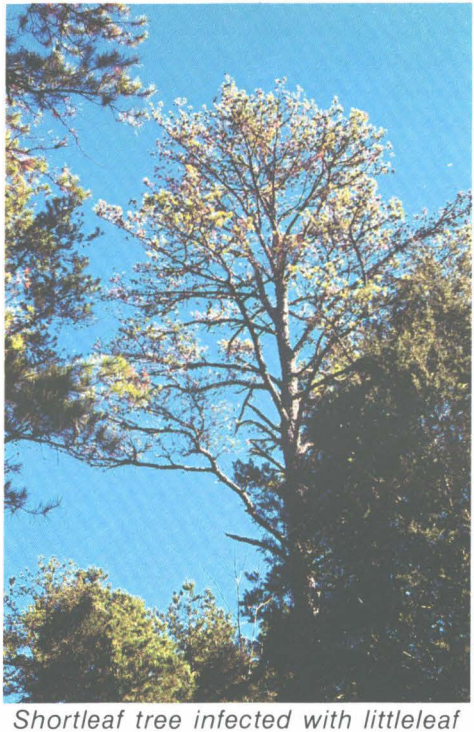
Importance.—Littleleaf disease is the most important disease affecting shortleaf pine in the South. Loblolly pine is also affected, but to a lesser degree. Affected trees often die within 6 years of first symptom expression.

Identifying the Causal Agents.—This disease is caused by a complex of factors which include *Phytophthora cinnamomi,* heavy clay soil, and soil that is low in nitrogen. Also, *Pythium* spp. and nematodes often contribute to the damage. While the soil can be evaluated on site, laboratory analysis is required for confirmation of the fungi, nematodes, and nitrogen deficiency.

Identifying the Injury.—While the damage is to the roots, the obvious symptoms are seen in the crown. The first symptom is needle yellowing. New needles are shorter and fewer in number. Eventually, the crown looks sparse and often has a tufted appearance. A heavy crop of small, very persistent cones normally develops 2 to 3 years prior to tree death. Often there is a flush of epicormic branches on the bole of the tree.

Biology.—This disease occurs on trees growing on low quality sites—such as old fields. For various reasons, including nitrogen depletion, poor aeration, and rootlet competition, the rate of new rootlet formation by the tree declines and the rate of loss resulting from the killing action of *P. cinnamomi* increases. On poor sites, infected trees showing early symptoms are expected to survive about 6 years. On better sites they may persist 15 to 20 years.

Control.—In the forest, losses can be minimized by salvage, favoring loblolly pine within its range, or, where silviculturally appropriate, converting to hardwood. In an urban or high value forest situation, a high nitrogen fertilizer can be used to delay mortality for as much as 6 to 12 years.



Shortleaf tree infected with littleleaf complex.

SAND PINE ROOT DISEASE,
caused by *Inonotus circinatus, Phytophthora cinnamomi, Phaeolus schweinitzii, Verticicladiella procera, Armillariella tabescens, Heterobasidion annosum*

Importance. — Sand pines are affected by a complex of root disease fungi acting alone or in various combinations. Trees of all ages and in all types of growing situations may be damaged or killed. Losses are especially severe in stands over 20 years old.

Identifying the Fungi. — Most of the fungi involved are discussed elsewhere in this guide. In the spring, *Armillariella tabescens* produces clusters of gilled, cream-colored mushrooms near the base of diseased, older trees. Perforated mats of fungus material are formed between the bark and wood of killed roots. *Phytophthora cinnamomi* must be cultured for positive identification.

Identifying the Injury. — Young trees may die suddenly or slowly, as isolated individuals or in groups. Dwarfed, yellow needles and slowed, radial growth are symptoms in older trees that die slowly. Windthrow is common. Affected roots and stems are resin-soaked and often exude resin through the bark.

Biology. — Young plantations are infected by *P. cinnamomi,* while natural stands are not. As trees age, *V. procera* and the other root rot fungi become established in both natural stands and plantations, and infect through wounds or root contacts.

Control. — Planting should be done only on sandy soils, 6 or more feet deep. Planted seedlings should be disease-free. Avoid root and butt injuries during stand entries. Stand rotations should be shortened to between 25 and 30 years.

Pitch flow through bark.

Resin soaking in main stem.

Damage of sand pine root disease.

WHITE PINE ROOT DISEASE, caused by *Verticicladiella procera*

Importance. — Until recently, white pine root disease was of greatest importance in Christmas tree plantations and newly established forest plantations. However, the fungus is now associated with dying, mature eastern white pines in natural stands in the southern Appalachians. Infection centers of up to a dozen trees have been found in mature sawtimber stands.

Identifying the Fungus. — There are no fruiting bodies associated with this fungus that can be seen with the unaided eye. However, the fungus can be readily identified when grown in pure cultures and observed under the microscope.

Identifying the Injury. — Affected, mature white pines may die from the top down, one whorl at a time. Older and younger trees alike may also turn yellow and lose some needles before turning brown uniformly. Some trees may die within a year after symptoms appear. Others may linger for several years, with mortality occurring apparently at random, and 1 to 3 percent of the affected trees dying annually. A chocolate-brown to dark olive-brown canker may occur under the bark around the root collar. However, cankers are not always present, and tree death may result from the killing of numerous small roots $^{3}/_{16}$ inch (5mm) in diameter and smaller.

Biology. — In Christmas tree and forest plantations, wet sites appear to favor the disease.

Control. — Avoid planting eastern white pine on wet areas. In young plantations, particularly Christmas tree plantations, either avoid replanting in areas of known infection or remove as much of the infected root systems as possible.

Basal canker caused by white pine root disease fungus.

URBAN TREE DECLINE

Importance. — Among the problems leading to urban tree decline are: air pollution, soil compaction, mower- and machine-caused injuries, poor pruning, heat reflected from streets and buildings, direct root damage from excavations and turf cultivation, paving, improperly applied herbicides, potting above and below ground level, overplanting, and lack of understanding about tree growth and development. For these and other reasons, urban trees generally suffer a diseased existence and must be frequently replaced. Those that survive are often aesthetically unpleasing.

Identifying the Cause. — In addition to the above, a variety of fungi can attack trees that have been weakened. Most are heart, butt, and root rotting fungi that can affect trees structurally, making them unsafe. Others attack the roots, causing the tops to die back. Only rarely will all the causal agents in urban decline be identified.

Identifying the Injury. — Identifying the injury is usually easy. Affected trees show a dieback of the crown, beginning with the uppermost and outermost branches first. In the final stages, the trees may have only a few green sprouts and leaves attached to the main stem.

Biology. — Tree crowns most frequently begin to die back when the roots have been damaged or are diseased. This is due to the fact that plants grow with a carefully balanced root/shoot ratio. When a portion of the roots ceases to function, a portion of the crown dies as well. Often, disease fungi enter the weakened portion of the tree and further damage it.

Control. — Protect, fertilize, and irrigate trees that are declining. Plant trees that are resistant to air pollution injury and drought, and provide trees with adequate root space and aeration. Remove dying trees to avoid danger to people and property.

Maple declining from paving - and possibly other factors.

Elm declining from construction and compaction.

AIR POLLUTION

Importance. — Chemical discharges into the atmosphere have increased dramatically during this century, but the total effect on forest tree crops is virtually unknown. It has been demonstrated that air pollutants can cause mortality and losses in growth of forest trees. Nearly all species of deciduous and coniferous trees are sensitive to some pollutants.

Identifying the Cause. — There are many chemicals released into the atmosphere singly and as compounds. In addition, other compounds are synthesized in the atmosphere. Some chemicals can be identified through leaf tissue analysis, while others can be detected by analyzing the air itself. Identifying the single chemical or chemicals that are the cause of tree damage in a polluted environment can be extremely difficult and should be left to one trained in this field.

Identifying the Injury. — Generally, pollution injury first appears as leaf injury. Spots between the veins, leaf margin discoloration, and tip burns are common. These symptoms can also be influenced by host sensitivity, which is effected by genetic characteristics and environmental factors. Symptoms similar to those caused by air pollution, but resulting from nutritional deficiencies, drought, and other stresses, are often confused with pollution injury.

Biology. — Many of the materials, such as sulfur dioxide, form acids inside leaves after they enter through the stomata. Others may enter the leaf tissue directly.

Control. — The best control is limiting atmospheric pollutants. Since this is difficult for the individual to do, the use of resistant plants is a practical alternative. Maintaining existing trees in a healthy condition will afford them some protection from air pollution damage.

Air pollution damage to white pine.

HERBICIDE DAMAGE,
caused by various chemicals

Importance. — Drift and misapplication of herbicides can often damage nontarget trees. The total extent of such damage remains unknown, but localized, severe damage occurs. All tree species can be damaged by herbicides.

Identifying the Causal Agent. — Identification of the causal chemical is done primarily through symptom expression of the tree and determination of the method and rate of nearby herbicide applications. Symptom expression can be variable for a given chemical and is often unreliable when used as the only diagnostic tool.

Identifying the Injury. — Symptoms of herbicide injury are variable due to chemical mode of action, dosage, duration of exposure, tree species, and environmental conditions. Some herbicides cause growth abnormalities such as cupping or twisting of foliage while others cause foliage yellowing or browning, defoliation, or death. Environmental conditions such as temperature and humidity affect the degree of symptom expression by the host. Since symptom expression is so variable, professional help is desirable in diagnosing the problem.

Control. — Protect trees from unwanted or misapplied herbicides.

Chemical burn to nursery stock.

PINEWOOD NEMATODE, *Bursaphelenchus xylophilus*

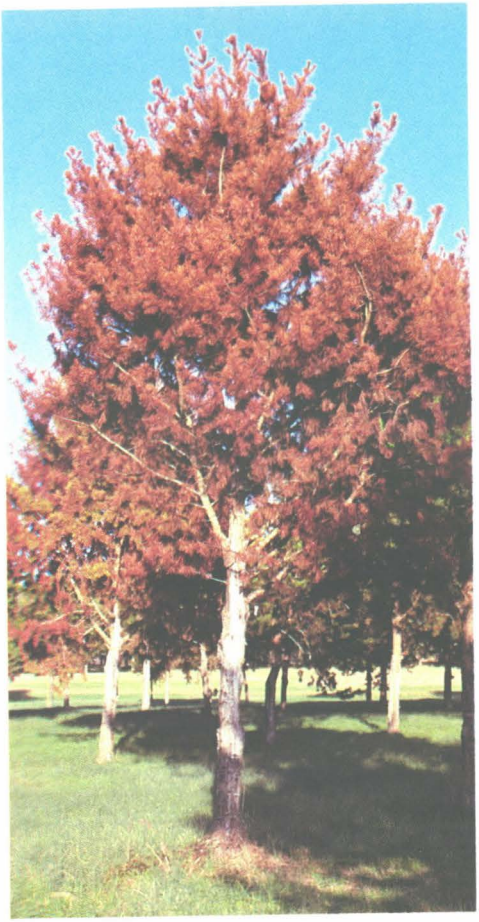
Importance.—The importance of the pinewood nematode as a forest disease agent in the United States is unknown. It may be native to our country. In Japan, where the nematode may have been introduced, as many as 20 percent of the trees in some stands have been killed. In this country, the disease has been found more often in shade trees. The disease occurs mostly on species of pine, particularly the nonnative species. It is rare on some other species of conifers.

Identifying the Parasite.—The pinewood nematode can be identified only through microscopic examination of a specimen.

Identifying the Injury.—Affected trees show symptoms of wilting, coupled with a significant reduction in resin flow. Wilted trees will turn from yellow to brown within 3 months after becoming infested.

Biology.—The nematode is carried from previously colonized dead pine by woodboring beetles in the genus *Monochamus*. The young adult beetles feed on young tissues of healthy trees and, in the process, inoculate them with nematodes.

Control.—At the present time, no control for nematodes is known in the United States. In Japan, chemical control for the beetles is being tested.



Virginia pine infested with pinewood nematode.

SLIME FLUX, caused by Bacteria

Importance.—This disease results in persistent, bad-smelling, bleeding cankers on the stem or at the base of many species of hardwoods. Oaks are the most seriously affected species. Incidence is low, but severe quality loss occurs to the infected tree.

Identifying the Cause.—The prime wounding agents are insect borers, mechanical injuries, and natural cracks and splits which are rarely observed. Clear sap flowing from the wound becomes colonized with bacteria, darkens, and develops an unpleasant odor. The specific bacteria causing the dark color and odor are rarely identified.

Identifying the Injury.—Patches of wet bark having a sour smell are generally the first symptom of this disease. In additon, insects are attracted to the wet area. Often the bark in the area of the slime flux separates from the tree bole and gives a hollow sound when tapped.

Biology.—Wounding of hardwoods causes sap to flow from the injured area. Bacteria colonize the sap causing the typical odor. The bacteria-laden fluid is toxic to the bark and enlarges the wound with time.

Control.—In the forest, practices that minimize wounding will reduce the spread of this disease. For urban trees, maintaining vigorous, healthy growing conditions (through fertilization, watering, and mulching) and avoiding wounds will reduce the probability that trees will be affected by this disease. Removing bark from the affected area will reduce damage to an individual tree.

Damp discoloration of slime flux.

MISTLETOE,
Phoradendron spp.

Importance.—Many species of hardwood trees are affected by mistletoe, but oaks and hickories are most commonly attacked. Mistletoe is used in Christmas greens and can be found throughout the South. The impact of infestation is not normally severe, but the parasite may lower individual branch vigor. Where infestations are severe, tree decline may progress to the point where insect and fungus pests combine to kill trees.

Identifying the Parasite.—Perennial, broad-leafed, evergreen plants appear in the tree crown. Identification is easier in winter, when the host tree's leaves are absent. The plant has opposite leaves and inconspicuous flowers that produce white to red berries in the fall.

Identifying the Injury.—The presence of the plant is the only reliable sign of an infestation.

Biology.—Seeds are animal- and bird-dispersed between and within tree crowns. A sticky substance on the seeds helps them adhere to susceptible young branches. Upon germination, a peglike root penetrates to the tree's vascular system, extracting water and needed nutrients.

Control.—Control is usually not necessary. If desired, tree branches may be pruned at least one foot back from the plant's attachment point, and then discarded.

Clusters of mistletoe.

Mistletoe plant.

PLANT PARASITES OF TREE ROOTS,

caused by members of the families *Olacaceae, Santalaceae, Scrophulariaceae, Orobanchaceae,* and *Krameriaceae*

Importance.—The impact of parasitic plants on stand and tree growth is not known in detail, except for a few species which attack young trees. Young slash pine in at least one Florida plantation have been killed by the root parasite senna seymeria (*Seymeria cassioides*). *Commandra umbellata* can parasitize roots of many species of plants and is also the alternate host for commandra stem rust of pines. Many of these parasitic plants have a wide geographic and host range.

Identifying the Parasites.—Root parasitic plants come from many genera. Many are green plants which can be treelike, shrublike, or herbaceous in growth form. They can be annual, biennial, or perennial weeds that can survive for varying periods without root penetration of hosts. Others are nongreen, succulent annuals, which require functional root attachments to survive and reproduce.

Identifying the Injury.—Reduced tree growth, sometimes leading to tree mortality, has been reported in a few cases. Infected roots have swollen pads of parasite root tissue (haustoria) where host penetration has occurred.

Biology.—The host range for most parasites—including herbaceous weeds and grasses and woody plants—is quite broad. However, a few are quite specific to a small group of related species. After seed germination, the radicle contacts a host root, and a holdfast is formed on the surface. A peglike root penetrates the host's root surface and grows into the water- and nutrient-conducting tissues, removing the materials needed for development. If no host root is contacted soon after germination, some parasites will die. Others can live long enough to bear seed without ever initiating root infections.

Control.—No control has been adequately investigated.

"Bear corn" parasite on oak roots.

GLOSSARY

Abdomen—The third and rearmost region of the insect body.

Aecium (pl. aecia)—One of the reproductive structures in the life cycle of a rust fungus. Aecia normally appear as blisters on the host plant.

Aeciospores—Spores produced in an aecium.

Alternate host—Host in the life cycle of a rust fungus on which the pycnial and aecial stages are formed.

Ascospores—Spores produced in a saclike structure (the ascus). This structure is typical of a large group of fungi, the Ascomycetes.

Basidiospore—A spore borne on the outside of the reproductive structure called a basidium. This structure is typical of the group of fungi called the Basidiomycetes.

Cambium—A layer, one- or two-celled thick, between the xylem and phloem in higher plants. The cambium produces both of these tissues, resulting in diameter growth.

Canker—A localized necrotic lesion of the cambium.

Chlorosis (adj. chlorotic)—The loss of green pigment in a plant due to the plants inability to produce chlorophyll.

Conk—A fruiting body of a wood decay fungus that bears basidia.

Dormant—Having growth, development, or other biological activity suspended; resting, inactive.

Dorsal—Of or relating to the back; belonging to or situated on or near the upper surface.

Epicormic—Growing from a dormant bud that has been exposed to light and air.

Frass—Solid larval excrement, as left by defoliators; wood fragments made by a wood-boring insect, usually mixed with excrement.

Fruiting Bodies—Any structure formed of mycelia that contains spore bearing cells.

Fungus (pl. fungi)—A nongreen plant with a vegetative body formed of tubular filamentous cells (hyphae). Fungi reproduce by spores.

Generation—Period of time required to complete the life cycle of an insect.

Gouting—Tumorlike swellings on boles, branches, or twigs, caused by feeding of sucking insects.

Haustorium (pl. haustoria)—A specialized structure of a pathogen that is capable of direct penetration into, and nutrient absorption from, a host plant.

Head—The first region of the insect body. Eyes, mouth parts, and antennae (where present) are attached in this region.

Honeydew—A sweetish secretion produced by sucking insects, particularly aphids and scales.

Host—A plant which provides nutrition for an invading parasite.

Host Range—The various plants which a pathogen can infect.

Infection—The establishment of a feeding relationship between a host and a parasite.

Infection Court—Point of entry and establishment of a pathogen in the host organism.

Instar—The life stages of an insect larva between molts.

Larva (pl. larvae)—A young insect differing fundamentally in form from the adult (compare to nymph).

Metamorphosis—Series of changes through which an insect passes in developing from egg to adult.

Mycelium—A mass of fungal filamentous cells. It forms the vegetative body of the fungal plant.

Mycoplasma—A group of microscopic organisms intermediate between bacteria and viruses.

Necrotic—Dead.

Nymph—Young stage of insect which does not fundamentally differ in form from the adult (compare to larva).

Parasite—An organism that lives on or in, and obtains its food from, another organism (host).

Parthenogenesis—Reproduction without male fertilization.

Pathogen—An agent that causes disease.

Perithecium (pl. perithecia)—A closed bulb- or ball-shaped fruiting body with a pore through which ascospores are extruded, usually in a gelatinous paste.

Primary host—The host of a rust fungus on which the telial stage of the fungus is produced.

Prothorax—First thoracic segment bearing the first pair of legs but no wings.

Pupa (pl. pupae)—The intermediate life stage between the larva and the adult.

Pupate—To become a pupa; to pass through a pupal state.

Resinosis—Exudation of pitch from a wound or infection on a conifer.

Resistance—The ability of a host to slow the development of a disease.

Resistance Breeding—The selection and deliberate propagation of those individuals in the population which display resistance to a specific pest.

Rhizomorph—A thick strand of mycelium in which the hyphae have lost their individuality; similar in appearance to a small root.

Saprophyte—Any organism which feeds on dead organic matter.

Segment—A subdivision of an animal body or appendage.

Sooty Mold—A dark or black velvety coating of mycelium of various fungi growing in insect honeydew on the leaves, fruit, or other exposed parts of plants.

Spores—The reproductive unit of fungi. Spores function in the same way that seeds do for higher plants.

Sporodochium (pl. sporodochia)—A cushion-shaped vegetative structure covered with spore bearing cells.

Stroma (pl. stromata)—A compact vegetative structure on, or within which, fruiting bodies are formed.

Telium (pl. telia)—Specialized fruiting structure of a rust fungus which produces teliospores. Generally, telia appear as hair-like filaments on the underside of leaves of the host.

Teliospores—In a rust fungus life cycle these resting spores are the normal over-wintering spore form. They germinate in the spring and generate basidiospores.

Thorax (Adj. thoracic)—The second (middle) region of the insect body. The six true legs are normally attached in this region.

Thoracic legs—True legs located on the second region of the insect body.

Uredium (pl. uredia)—One of the five reproductive tissues in the complete rust life cycle. This tissue gives rise to a large number of spores on a continuous basis for an extended period of time.

Urediospores—Spores produced in a uredium.

Vector—Any organism that transmits a disease-causing organism.

Ventral—Of or relating to the belly; belonging to or situated on or near the lower surface.

Windthrow—The uprooting or overturning of trees by the wind.